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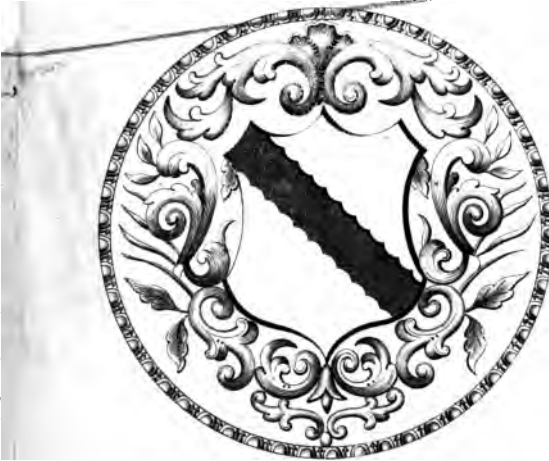
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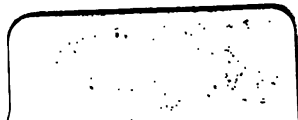


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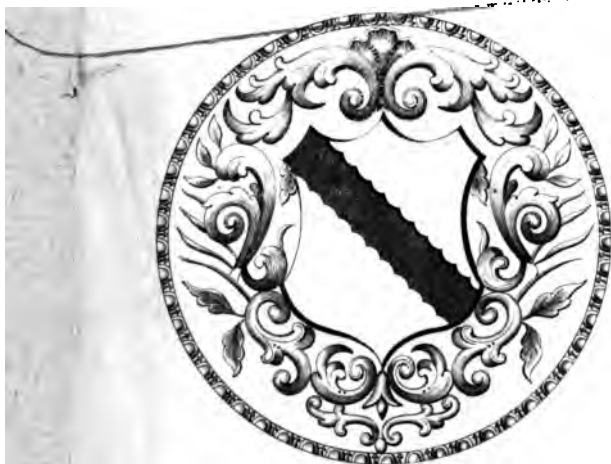
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E L E M E N T S
O F
C H E M I S T R Y.

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C O N T E N T S

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PART THE FOURTH.

CONCERNING VEGETABLE SUBSTANCES.

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ELEMENTS OF CHEMISTRY.

PART THE FOURTH. CONCERNING VEGETABLE SUBSTANCES.

INTRODUCTION.

THE mineral bodies upon which we have hitherto treated, possess no life, or vital principle, properly speaking; neither do they exhibit any phenomena dependant upon internal organization. The crySTALLIZATION affected by substances of this kingdom, appears to be exceedingly different from the organization of

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living

living beings. It produces no advantage to the individual; and at most serves only to prove the great harmony of nature, which marks its several productions with constant and invariable forms. But the organization of vegetable and animal beings disposes those bodies in such a manner as is respectively the most proper to accomplish the two final purposes of nature; namely the subsistence and reproduction of the individual.*

It cannot be denied that vegetables are endowed with a principle of irritability, which develops in them, both sensation and motion: the motion is so evident in certain plants, that it may be produced at pleasure, as in the sensitive plant, the stamina of the opuntia, &c. The plants which follow the course of the sun; those which in hot-houses incline towards the apertures that admit the light; other plants which contract and shut up by the puncture of an insect; those whose roots turn out of their direct or original course to plunge themselves into a favourable soil, or water—have not these a degree of sensation of touch which may be com-

* For the development of these principles, see *La Thèse sur l'Analyse Végétale*, supported at the schools of Montpellier by my scholar and friend, M. Riché.

pared to the sensibility of animals? The difference of the secretions in various organs, supposes a difference in the irritability of each respective part.

The reproduction of vegetables is effected in the same manner as that of animals; and modern botanists have supported the comparison between these two functions in the most happy and conclusive manner.

Vegetables are nourished with air in the same manner as insects. This aliment is even of indispensable necessity, for without it the plant at last perishes; though the air which this order of beings requires, is neither of the same purity nor of the same kind.

The great difference which exists between vegetables and animals is, that the latter in general are capable of conveying themselves from place to place, in search of nourishment; whereas vegetables, being fixed in the same place, are obliged to take up in their own vicinity all such matters as are capable of nourishing them: and nature has provided them with leaves, to extract from the atmosphere the air and water of which they have need; while their roots extend to a distance in the earth, to take firm hold, as well as to receive other nutritive principles.

If we attend more minutely to the character of animals, we shall perceive that nature descends by imperceptible degrees from animals of the most complicated organization to vegetables; and we shall find it difficult to determine where one kingdom terminates, and the other begins. Chemical analysis is capable of marking the limits between these kingdoms in an imperfect manner. For a long time it was pretended that animal substances possessed the exclusive property of affording ammoniac, or the volatile alkali; but it is at present well known that certain plants likewise afford it. We may in strictness consider a vegetable, as a being that participates in the laws of animal life, but in a less degree than the animal itself.

The difference which has been established between the vegetable and the mineral kingdoms, is much more striking. We may consider this last as a mass deprived of organization, and almost in an elementary state; receiving no modifications or changes but by the impression of external objects; capable of entering into combinations; of changing its nature; and of re-appearing, or being reproduced with its original properties, at the pleasure of the chemist. The other kingdom, on the contrary, being endued with a particular life, which incessantly

incessantly modifies the impression of external objects, decomposing them, and changing their nature, exhibits to us a series of functions regular throughout, and almost all of them inexplicable; and when the chemist has succeeded in depriving these bodies of their organization, and separating their principles, he finds it beyond his power to reproduce it by any re-union of the same principles.

In the mineral kingdom, we are justified in referring all the phenomena to the action of external bodies; and forces purely physical, or the simple laws of affinity, afford deductions sufficient to account for all its metamorphoses. In the vegetable kingdom, on the contrary, we are compelled to acknowledge an internal force which performs every thing, governs all the processes, and subjects to its designs those agents which have an absolute empire over the mineral kingdom.

The mineral possesses no evident life, no period which may be considered as the term of its perfection; because its various states are always relative to the purposes to which we intend to apply it. It does not appear either to grow or to be reproduced: at most it changes its form, but never by any internal determination; this is always the mere physical effect of the action of external objects. In those cases wherein the
mineral

mineral exhibits marks of increase or vegetation, it is by the successive application of similar materials worn and transported by the waters. In these apparent vegetations we perceive neither elaboration nor design: the law of affinities ever presides in these arrangements; and this law is the law of bodies void of life.

It is not therefore surprising that the chemical analysis should have made less progress in the vegetable than in the mineral kingdom, for it becomes more difficult in proportion as the functions are complicated; and in the vegetable kingdom the constituent parts are more numerous, at the same time that they are less easily distinguished by characteristic properties; and the methods of analysis hitherto employed are all imperfect; not to mention that the proceedings of chemists have likewise been conducted upon an erroneous principle.

All plants have hitherto been analysed either by fire or by menstruums. The first of these methods is very uncertain; for the action of fire decomposes combined bodies, alters their principles, forms new bodies by the combination of these separate elements, and extracts nearly the same principles from very different substances. Long experience has shewn the imperfection

perfection of this method. Messrs. Dodart, Bourdelin, Tournefort, and Boulduc, have distilled more than fourteen hundred plants; and it was from the results of so extensive a work that Homberg deduced sufficient reasons to conclude that this method is erroneous. As a proof of his assertion, he quotes the analysis of cabbage and hemlock, which afforded the same principles by distillation.

The method by menstruums is somewhat more accurate, because it does not change the nature of the products: it has been even of greater advantage to medicine, by affording methods of separating the medicinal principle from certain vegetables. It has also afforded its assistance to extract other principles in all their purity, which are useful in the arts, or for the purposes of life; and it has given us more instruction concerning the nature of vegetable principles. But we cannot confine ourselves to this single method in the analysis of plants; and a considerable share of genius is required in the chemist, to vary his process according to the nature of the vegetable, and the character of the principle he is desirous of extracting.

A reproach of considerable weight may be urged against most of the chemists who have written upon the vegetable analysis: it is, that
I they

they have followed no order in their proceedings, nor attended to any regular distribution of the facts. They have confined themselves to indicate processes for extracting such or such substances, without connecting the whole with any system founded either on the methods of operating, on the nature of the products, or on the proceedings followed by nature in its own operations. I confess that, if a disquisition on the vegetable analysis were to be confined to the processes necessary to be known in extracting the several substances, the system of order and of method which I propose would be useful; but if it be an object to know the operation of nature, and to survey the vegetable kingdom like a philosopher, a naturalist, and a chemist, it is necessary to inspect the operations of nature herself among vegetables, and to follow as much as possible a plan which shall render us acquainted with the plant under all these points of view: that which I have adopted appears to me to answer that purpose.

We shall begin by exhibiting a cursory account of the vegetable structure, in order that we may become better acquainted with the connection between its organization and the principles which we shall extract.

In the second place we shall attend to the develop-

development and increase of the vegetable. With this intention we shall shew the various principles which serve for its nourishment; and we shall follow their alterations in the vegetable œconomy as much as we are enabled to do. We shall therefore of consequence examine the influence of the air, the soil, the light, &c.

In the third place we shall examine the results of the work of organization upon elementary substances; and for that purpose we shall teach the method of distinguishing the several constituent principles of vegetables; taking care to proceed in this examination according to that method which nature herself points out.

Thus we shall begin with the analysis of such products as we can extract without destroying the organization of the plant, and which are exhibited in a naked state by that organization: such as the mucilage, the gums, the oils, the resins, the gum resins, &c. We shall in the next place analyse such principles as cannot be collected but by destroying the organization of the plant; such as the secula, the glutinous part, the sugar, the acids, the alkalis, the neutral salts, the colouring principles, the extractive matter, iron, gold, manganese, sulphur, &c.

We shall likewise attend to the prolific humours of vegetables; that is to say, the examination

nation of such substances as, though necessary to life, are urged outwards to answer certain functions: the pollen and honey are of this kind.

We shall afterwards examine the humours which evaporate and escape by transpiration; such as oxygenous gas, the aqueous principle, the aroma, or odorant principle, &c.

And in the last place we shall shew the alterations to which vegetables are subjected after death. In order to proceed with regularity in a question of such great importance, we shall successively examine the action of heat, of the air, and of water, upon the vegetable, whether they act separately or together. This proceeding will render us acquainted with all the phenomena exhibited by vegetables in their decomposition.

SECTION I.

Concerning the Structure of Vegetables.

EVERY vegetable exhibits in its structure. 1. A fibrous and hard mechanism, which supports all the other organs, determines the direction, and gives the proper solidity to the several plants and their parts. 2. A cellular tissue, which accompanies all the vessels, envelops all the fibres, contorts itself in a thousand ways, and every where forms coverings and a net-work which connect all the parts, and establish an admirable communication between them. We shall describe the several parts of plants in a very concise manner, and shall confine ourselves to the explanation and description of such organs as must necessarily be known with accuracy, before we can proceed to the analysis of plants.

ARTI-

A R T I C L E I.

Concerning the Bark.

The bark is the external covering of plants: its prolongations or extensions cover all the parts which compose the vegetable. We may distinguish three particular tunics, which may be separately detached and observed; the epidermis, the cellular tissue, and the cortical coatings.

1. The epidermis is a thin membrane, formed of fibres that cross each other in every direction: its texture is sometimes so thin, that the direction of its fibres may be seen by holding it against the light. This membrane is easily detached from the bark when the plant is in a vigorous state; and when it is dried the separation may be effected by steeping it in water. When the epidermis of a plant is destroyed, it grows again; but is then more strongly adherent to the rest of the bark, so as to form a kind of cicatrice.

This epidermis appears to be intended by nature to modify the impressions of external objects upon the vegetable; to furnish a great number of pores, which transmit or throw off
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the excretory products of vegetation; to protect the last or extreme ramification of the aërial or aqueous vessels, which extract out of the air such fluids as are necessary for the increase of the vegetable; and to cover the cellular organ, which contains the principal vessels, and those glands in which the several fluids are digested and elaborated.

2. The cellular coating forms the second part of the bark. Its texture consists of vesicles and utricles, so very numerous, and so close together, as to form a continued coating. It is among these glands that the work of digestion appears to be performed; and the product of this elaboration is afterwards conveyed through the whole vegetable, by vessels propagated through all its parts and communications; even with the medullary substance or pith, by conduits that pass through the body of the tree, crossing the ligneous strata. In this net-work it is that the colouring matter of vegetables is developed: the light which penetrates the epidermis concurs in enlivening the colour: here likewise it is that oils and resins are formed, by the decomposition of water and the carbonic acid; and lastly it is from this reticular substance that those various products of the organization are thrown off or excluded, which

which may be considered as the *faces* of the vegetable digestion.

3. The coatings which lie between the external covering and the wood or body of the vegetable, and may be called the cortical coatings, are formed of laminæ which themselves consist of the re-union of the common, proper, and air-vessels of the plant. The vessels are not extended lengthwise along the stem, but are curved in various directions, and leave openings or meshes between them, which are filled by the cellular matter itself. Nothing more is necessary to shew the organization, than to macerate these coatings in water, which destroys the cellular substances, and leaves the net-work uncovered.* The cortical coverings are easily detached from each other; and it is from their gross resemblance to the leaves of a book, that they have been called *liber*. In proportion as these coatings approach the ligneous body, they become hard; and at length form the external softer part of the wood, which workmen call the sap.

The bark is the most essential part of the vegetable, by means of which the principal func-

* This is most particularly seen in the *arbre à dentelle*, when the plant has been macerated in water.

tions of life, such as nutrition, digestion, the secretions, &c. are performed. All plants, and particularly those which are hollow within, and whose products are totally changed by covering them with a different bark, prove evidently that the digestive force eminently resides in this part. The ligneous part is so far from being essential, that many plants are without it, such as the gramineous and the arundinaceous, and all plants that are hollow within. Grasses, properly speaking, have only the cortical part. We often see plants internally rotten, but kept in vigour by the good state of their bark.

ARTICLE II.

Concerning the Ligneous Texture.

Beneath the bark there is a solid substance, which forms the trunk of trees, and appears to be usually composed of concentric layers. The interior coatings or rings are harder than the exterior; they are older, and of a more firm and close grain. The hardest of these form the wood, properly so called, while the softer external rings constitute the sap. We may consider wood as being formed of fibres, more or less longitudinal, connected together by a cellular

lular tissue, interspersed with vesicles communicating with each other, which diminish gradually towards the centre, where they form the pith. The pith is found only in young branches or plants, and disappears in plants of a certain age.

The vesicular tissue bears a great analogy with the glandular and lymphatic vessels of the human body: in both, the conformation and uses are the same. In the early age of plants and animals, the organs have a considerable expansion, because the increase of the individual is very rapid at that period. But, as age advances, the vessels become obliterated in both kingdoms; and it is observed that, in the white woods and fungi which abound with the vesicular substance, the growth is also very rapid.

A R T I C L E III.

Concerning the Vessels.

The various humours of vegetables are contained in certain appropriated vessels, in which they enjoy a degree of motion that has been compared to the circulation in animals. It differs from it, however; because these humours are not continually kept in equilibrio in the vessels

vessels by an inherent force, but receive in a more evident manner the impression of external agents. Light and heat are the two great causes which determine and modify the motion of the fluids and vegetables. These agents cause the sap to rise into the various parts, where it is elaborated in a manner correspondent to the functions of each; but it is not observed that it returns; so that the accession or flux of the humours in vegetables is proved, but the reflux does not appear to be perceptible.

Three kinds of vessels may be distinguished in vegetables; the common, or sap vessels; the proper vessels; and the air vessels, or tracheæ.

1. The sap vessels convey the sap, or general humour, from which all the others are derived. This liquor may be compared to the blood in animals. These vessels are reservoirs from which the several organs extract the different juices, and elaborate them in a proper manner.

The sap vessels chiefly occupy the middle of plants and trees. They rise perpendicularly, though with deflexions sideways, so as to communicate with all the parts of the vegetable. They convey the sap into the utricles; whence it is taken by the proper vessels, in order that it may be duly elaborated.

2. Each organ is likewise provided with

peculiar vessels, to separate the various juices, and to preserve them, without suffering them to mix with the general mass of humours. Thus it is that we find in the same vegetable, and frequently in the same organ, juices of different natures, and greatly differing in colour and consistence.

The vessels, whether common or proper, are retained in their several directions by the ligneous fibres; they are every where surrounded by the cellular tissue; they open, and pour their fluids into the glands, into the cellular tissue, and into the utricles, to answer the various functions.

The utricles are small vessels or repositories which contain the pith, and frequently the colouring matter. They form a kind of repository in which the nutritive juice of the plant is preserved, and whence it is taken on occasion; in the same manner as the collection of marrow is formed in the internal part of the bones, whence it is afterwards extracted when the animal is not sufficiently supplied with nutriment.

3. The tracheæ, or air-vessels, appear to be the organs of respiration, or rather those which receive the air, and facilitate its absorption and decomposition. They are called tracheæ on account of the resemblance which is thought to exist between them and the respiratory or-

gans of insects. In order to observe them, a branch of a tree is taken sufficiently young to break off short: after having cleared away the bark without touching the wood, the bough is broken by drawing the two extremities in opposite directions; the tracheæ are then seen in the form of small corkscrews, or vessels turned in a spiral direction. It is generally supposed that the large pores which are perceived in the transverse section of a plant, viewed in a microscope are merely air-vessels. It often happens that the sap is extravasated in the cavity of the tracheæ; and they appear incapable of serving any other purposes than that of conveying the air, at least for some time, unless a change take place in the life of the plant.

A R T I C L E I V.

Concerning the Glands.

Small protuberances are observed upon various parts of vegetables. These are glandular bodies, whose form is prodigiously varied. It is more particularly upon this variation of form that Mr. Guettard has grounded his seven species. They are almost always filled with a humour, whose colour and nature are singularly varied.

SECTION II.

Concerning the Nutritive Principles of Vegetables.

IF plants were to perform no other act than that of pumping the nutritive principles they contain out of the earth; if they did not possess the faculty of digesting, assimilating them, and forming different products, according to their nature, and the diversity of their organs; it would follow, as a consequence, that we ought to find in the earth all those principles which analysis exhibits to us in vegetables: a conclusion which is contradicted by the facts; for we shall hereafter prove, that the production of vegetable earth is an effect of the organization of plants, and that it owes its formation to them instead of communicating principles ready formed to those individuals. If it were true that plants did nothing but extract their component parts out of the earth, those plants which grow on the same soil would possess the same principles, or at least the analogy between them would be

be very great; whereas we find plants of very different virtues and flavours grow and flourish beside each other. In addition to this we may observe, that such plants as are raised in pure water—the fat plants, which grow without being fixed to the earth, provided they are placed in a moist atmosphere—the class of parasitical plants, which do not partake of the properties of those which serve to support them—prove that a vegetable does not derive its juices from the earth, on account of its being earth; but that it possesses an internal alterative and assimilating power, which appropriates to each individual the aliment which is suitable to it, at the same time that it disposes and combines that aliment to form certain peculiar principles. This digestive virtue will appear to be astonishingly perfect, when it is considered that the nutriment common to all vegetables is very little varied, since we know only of the water and air; and consequently that it possesses the power of forming very different products with these two simple principles. But from this circumstance, that the nutritive principles of plants are very simple, it must be presumed that, in the various results of digestion, or (which is the same thing) in the vegetable solids and fluids, there must be the greatest analogy; and that the differences

ferences are deducible from the proportion of the principles, and their more or less perfect combination, rather than from their variety.

With this intention we shall carefully observe the transition from one principle to another; and shall explain the art of reducing them all to certain elementary or primitive substances, such as the fibrous matter, mucilage, &c.

ARTICLE I.

Concerning Water, as a Nutritive Principle of Plants.

Every one knows that a plant cannot vegetate without the assistance of water: but it is not so generally known that this is the only aliment which the root draws from the earth; and that a plant can live, and propagate itself, without any other assistance than the contact of water and air. It appears to me, nevertheless, that the following experiments remove every doubt on the subject:—Van Helmont planted a willow, weighing fifty pounds, in a certain quantity of earth covered with sheet lead: he watered it for five years with distilled water; and at the end of that time the tree weighed one hundred

hundred and sixty-nine pounds three ounces, and the earth in which it had vegetated was found to have suffered a loss of no more than three ounces. Boyle repeated the same experiment upon a plant, which at the end of two years weighed fourteen pounds more, without the earth in which it had vegetated having lost any perceptible portion of its weight.

Messrs. Duhamel and Bonnett supported plants with moss, and fed them with mere water; they observed that the vegetation was of the most vigorous kind; and the naturalist of Geneva observes, that the flowers were more odouriferous, and the fruit of a higher flavour. Care was taken to change the supports before they could suffer any alteration. Mr. Tillet has likewise raised plants, more especially of the gramineous kind, in a similar manner; with this difference only, that his supports were pounded glass, or quartz in powder. Hales has observed that a plant which weighed three pounds gained three ounces after a heavy dew. Do we not every day observe hyacinths and other bulbous plants, as well as gramineous plants, raised in saucers or bottles containing mere water?

All plants do not demand the same quantity of water; and nature has varied the organs
of

of the several individuals conformably to the necessity of their being supplied with this food. Plants which transpire little, such as the mosses and the lichens, have no need of a considerable quantity of this fluid; and accordingly they are fixed upon dry rocks, and have scarcely any roots: but plants which require a larger quantity have roots which extend to a great distance, and absorb humidity throughout their whole surface.

The leaves of plants have likewise the property of absorbing water, and of extracting from the atmosphere the same principle which the root draws from the earth. But plants which live in the water, and as it were swim in the element which serves them for food, have no need of roots; they receive the fluid at all their pores: and we accordingly find that the fucus, the ulva, &c. have no roots whatever. The purer the water, the more salutary it is to plants. Mr. Duhamel has drawn this consequence from a series of well-made experiments, by which he has proved that water impregnated with salts is fatal to vegetation. Hales caused them to absorb various fluids, by making incisions in their roots, and plunging them in spirits of wine, mercury, and various saline solutions; but he was convinced that these were all poisons to the vegetables.

Besides,

Besides, if these salts were favourable to the plants, they would be again found in the individual which had been watered with a solution of them; whereas Messrs. Thouvenel and Cornette have proved that these salts do not pass into the vegetable. We must nevertheless except the marine plants, because the sea salt of which they have need is decomposed in them, and produces a principle which appears necessary to their existence, since they languish without it.

Though it is proved that pure water is more proper for vegetation than water charged with salts, it must not on that account be concluded that water cannot be disposed in a more favourable manner to the development of vegetables, by charging it with the remains of vegetable and animal decomposition. If, for example, the water be loaded with principles disengaged by fermentation or putrefaction, the plant then receives juices already assimilated to its nature; and these prepared aliments must hasten its growth. Independent of those juices already formed, the nitrogene gas, which constitutes one of the nutritive principles of plants, and is abundantly afforded by the alteration of vegetables and animals, must facilitate their development. A plant supported by the remains of vegetables and animals, is in the same situation

situation as an animal fed on milk only; its organs have less difficulty in elaborating this drink, than that which has not yet been animalized.

The dung which is mixed with earths, and decomposed, not only affords the alimentary principles we have spoken of, but likewise favours the growth of the plant by that constant and steady heat which its ulterior decomposition produces. Thus it is that Fabroni affirms his having observed the development of leaves and flowers in that part of a tree only which was in the vicinity of a heap of dung.

A R T I C L E II.

Concerning Earth, and its Influence in Vegetation.

Although it be well proved that pure water is sufficient for the support of plants, we must not consider the earth as of no use. Its utility resembles that of the placenta, which of itself affords no support to the life of the infant, but which prepares and disposes the blood of the mother to become a suitable nourishment: or it resembles, and has a similar utility with, the
various

various reservoirs which nature has placed in the body of man, to preserve the several humours, and emit them upon occasion. The earth imbibes and retains water: it is the reservoir destined by nature to preserve the elementary juice which the plant continually requires; and to furnish that fluid in proportion to its wants, without exposing it to the equally fatal alternatives of being either inundated or dried up.

We even see that, in the young plant or embryo, nature has not chosen to entrust the labour of digestion to the still feeble germen. The seed is formed of a parenchyma, which imbibes water, elaborates it, and does not transmit it to the germen, until it is reduced into juice or humour. By insensible gradations this seed is destroyed; and the plant, become sufficiently strong, performs the work of digestion without assistance. In the same manner it is that we perceive the fœtus supported in the womb of its mother by the humours of the mother herself; but, when it has seen the light, it receives for nourishment a fluid less animalized, its organs are gradually strengthened, and at length become capable of digesting a stronger and less assimilated nourishment.

But on this very account, that the earth is
destined

destined to transmit to the plant that water which is to support it, the nature of the soil cannot be a matter of indifference, but must be varied accordingly as the plant requires a more or less considerable quantity of water, accordingly as it demands more or less in a given time, and accordingly as its roots extend to a greater or less distance. It may therefore be immediately perceived that every kind of earth is not suitable for every plant, and consequently that a slip cannot be grafted indifferently upon every species.

A proper soil is that—1. Which affords a sufficiently firm support to prevent the plant from being shaken. 2. Which permits the roots to extend themselves to a distance with ease. 3. Which becomes impregnated with humidity, and retains the water sufficiently that the plant may not be without it when wanted. To answer these several conditions, it is necessary to make a proper mixture of the primitive earths, for none of them in particular possesses them. Siliceous and calcareous earths may be considered as hot and drying, the argillaceous as moist and cold, and the magnesian as possessing intermediate properties. Each in particular has its faults, which render it unfit for culture: clay absorbs water, but does not communicate it; calca-

calcareous earth receives and gives it too quickly: but the properties of these earths are so happily opposed, that they correct each other by mixture. Accordingly we find that, by adding lime to an argillaceous earth, this last is divided; and the drying property of the lime is mitigated, at the same time that the stiffness of the clay is diminished. On these accounts it is that a single earth cannot constitute manure; and that the character of the earth intended to be meliorated ought to be studied, before the choice of any addition is decided on. Mr. Tillet has proved that the best proportions of a fertile earth for corn, are three-eighths of clay, two-eighths of sand, and three-eighths of the fragments of hard stone.

The advantage of labour consists in dividing the earth, aerating it, destroying useless or noxious plants, and converting them into manure, by facilitating their decomposition.

Before we had acquired a knowledge of the constituent principles of water, it was impossible to explain, or even to conceive, the growth of plants by this single aliment. In fact, if the water were an element, or indecomposable principle, it would afford nothing but water entering into the nutrition of the plant, and the vegetable would of course exhibit that fluid only:

only: but when we consider water as formed by the combination of the oxygenous and hydrogenous gases, it is easily understood that this compound is reduced to its principles; and that the hydrogenous gas becomes a principle of the vegetable, while the oxygen is thrown off by the vital forces. Accordingly we see the vegetable almost entirely formed of hydrogen. Oils, resins, and mucilage, consist of scarcely any thing but this substance; and we perceive the oxygenous gas escape by the pores, where the action of light causes its disengagement. This decomposition of water is proved not only in vegetable, but likewise in animal bodies. Rondelet (*Lib. de Pisc.* lib. i. cap. 12.) cites a great number of examples of marine animals which cannot subsist but by means of water, by the very constitution of their organs. He affirms that he kept, during three years, a fish in a vessel constantly maintained full of very pure water: it grew to such a size, that at the end of that time the vessel could no longer contain it. He relates this as a very common fact. We likewise observe the red fishes, which are kept in glass vessels, are nourished, and grow, without any other assistance than that of the water properly renewed.

ARTICLE III.

Concerning Nitrogenous Gas, as a Nutritive Principle of Plants.

Vegetables cannot live without air; but the air they require is not the same as is appropriated to man. Drs. Priestley, Ingenhoufs, and Mr. Senebier, have proved that it is the nitrogenous gas which more particularly serves them for aliment. Hence it arises that vegetation is more vigorous when a greater quantity of these bodies which afford this gas by their decomposition are presented to the plant; these are, animals or vegetables in a state of putrefaction. As the basis of nitrogenous gas is unknown to us, it is difficult to conceive what may be its effect upon the vegetable œconomy, and we cannot follow it after its introduction into the vegetable. We do not find it again until the decomposition of the vegetable itself, when it reappears in the gaseous form.

ARTICLE IV.

Concerning the Carbonic Acid, as a Nutritive Principle of Vegetables.

The carbonic acid which is dispersed in the
atmo-

atmosphere, or in waters, may likewise be considered as an aliment of plants; for these bodies possess the power of absorbing and decomposing it when its quantity is small. The base of this acid even seems to contribute to the formation of vegetable fibres: for I have observed that this acid predominates in the fungus, and other subterraneous plants. But by causing these vegetables, together with the body upon which they are fixed, to pass by imperceptible gradations from an almost absolute darkness into the light, the acid very nearly disappeared; the vegetable fibres being proportionally increased, at the same time that the resin and colouring principles were developed by the oxygen of the same acid. Senebier has observed, that the plants which he watered with water impregnated with the carbonic acid, transpired a much greater quantity of oxygenous gas; which proves a decomposition of the carbonic acid.

Vegetation may therefore be successfully employed to correct air too highly charged with carbonic acid, or in which the nitrogenous gas exists in too great a proportion.

ARTICLE V.

Concerning Light, and its Influence on Vegetation.

Light is absolutely necessary to plants. Without the assistance of this principle they become pale, languish, and die. But it has not been proved that it enters as an aliment into their composition: at most it may be considered as a stimulus or agent which decomposes the various nutritive principles, and separates the oxygenous gas arising from the decomposition of water, or the carbonic acid, while their bases become fixed in the plant itself.

The most immediate effect of the fixation of the various substances, and the concretion of the liquids which serve as the food of plants, is a sensible production of heat, which causes plants to participate very little in the temperature of the atmosphere. Dr. Hunter observed, by keeping a thermometer plunged in a hole made in a sound tree, that it constantly indicated a temperature several degrees above that of the atmosphere, when it was below the fifty-sixth division of Fahrenheit; whereas the vegetable heat, in hotter weather, was always several de-

degrees below that of the atmosphere. The same philosopher has likewise observed, that the sap which, out of the tree, would freeze at 32° , did not freeze in the tree unless the cold were augmented 15° more.

The vegetable heat may increase or diminish by several causes, of the nature of disease; and it may even become perceptible to the touch in very cold weather, according to Mr. Buffon.

The heat produced in healthy vegetables, by the before-mentioned causes, continually tempers the cold of the atmosphere; the evaporation which takes place through the whole body of the tree, continually moderates the scorching heat of the sun; and these productive causes of cold or heat are more effectual, in proportion as the heat or cold of external bodies acts with greater energy.

The property which plants possess of converting nitrogenous gas and carbonic acid into nourishment, establishes an astonishing degree of analogy between them and certain insects. It appears, from the observation of Frederic Garman (*Ephem. des Curios. Nat. Année 1670*), that the air may become a real food for the class of spiders. The larvæ of the ant, as well as of several insects of prey which live in the sand, increase in bulk, and undergo their metamorphoses

phoses without any other nourishment than that of the air. It has been observed that a great number of insects, particularly in the state of larvæ, are capable of living in the nitrogenous gas, mixed with carbonic acid, and transpiring vital air. The abbé *Fontana* has observed that several insects possess this property; and *Ingenbousz*, who is of opinion that the green matter which is formed in water, and transpires oxygenous gas by the light of the sun, is a cluster of animalculæ, has added to these phænomena. Insects have moreover the organ of respiration distributed over the whole surface of their bodies. Here therefore we observe several very astonishing points of analogy between insects and vegetables; and the chemical analysis adds still more to the resemblances, since insects and vegetables afford the same principles; namely, volatile oils, resins, disengaged acids, &c.

S E C T I O N I I I .

Concerning the Results of Nutrition, or the
Vegetable Principles.

THE various substances which afford food to plants, are changed by the organization of the vegetable; from which there results a fluid generally distributed, and known by the name of Sap. This juice, when conveyed into the several parts of the plant, receives an infinity of modifications, and forms the several humours which are separated and afforded by the organs. It is to these principles chiefly that we are at present about to direct our attention; and we shall endeavour in our examination to follow the most natural order, by subjecting them to analysis in the same order as that in which nature presents them to us.

A R T I C L E I .

Concerning Mucilage.

Mucilage appears to constitute the first alteration of the elementary juices in vegetables.

Most

Most seeds are almost totally resolvable into mucilage, and young plants seem to be entirely formed of it. This substance has the greatest analogy with the mucous fluid of animals. Like that fluid, it is most abundant in the earlier periods of life, and all the other principles appear to be derived from it; and in vegetables, as well as animals, its quantity becomes less in proportion as the increase of magnitude, or growth of the individual, becomes less, or ceases. Mucilage is not only the nutritive juice of plants and animals; but, when extracted from either, it becomes the most nourishing and wholesome food we are acquainted with.

Mucilage forms the basis of the proper juices, or the sap, of plants. It is sometimes found almost entirely alone, as in mallows, the seeds of the wild quince, linseed, the seeds of thlaspi, &c. Sometimes it is combined with substances insoluble in water, which it keeps suspended in the form of an emulsion; as in the euphorbium, celandine, the convolvulus, and others. In other instances it is united with an oil, and forms the fat oils. Frequently it is united with sugar, as in the gramineous seeds, the sugarcane, maize, carrot, &c. It is likewise found confounded with the essential salts, with excess of acid, as in barberries, tamarinds, sorrel, &c.

Muci-

Mucilage sometimes constitutes the permanent state of the plant; as in the tremella, the conferva, some lichens, and most of the champignons. This existence in the form of mucilage is likewise seen in certain animals; such as the medusa or sea-nettle, the holothurion, &c.

The characters of mucilage are—1. Infipidity. 2. Solubility in water. 3. Insolubility in alcohol. 4. Coagulation by the action of weak acids. 5. The emission of a considerable quantity of carbonic acid, when exposed to the action of fire; at the same time that it becomes converted into coal, without exhibiting any flame. Mucilage is likewise capable of passing to the acid fermentation when diluted with water.

The formation of mucilage appears to be almost independent of light. Those plants which grow in subterraneous places abound with it. But light is required to enable mucilage to pass to other states; for, without the assistance of this principle, the same plants would obtain scarcely any consistence.

That which is called gum, or gummy juices, in commerce, is nothing but dried mucilage. These gums are three in number. They either flow naturally from the trunk of the tree which affords them, or they are obtained by incision of the bark.

1. Gum

1. Gum of the country, *Gummi nostras*.—This gum flows naturally from certain trees in our climate, such as the plum, the peach, the cherry-tree, &c. It first appears in the form of a thick fluid, which congeals by exposure to the air, and loses the adhesive and gluey consistence which characterizes it in the liquid state. Its colour is white, but more commonly yellow or reddish. When pure, it may be advantageously substituted for gum arabic, which is much dearer.

2. Gum arabic.—The gum arabic flows naturally from the acacia in Egypt and Arabia. It is even affirmed that it is not obtained from this tree only, but that the gum met with in commerce is the produce of several trees. The appearance of this gum is in round pieces, white and transparent, wrinkled without, and hollow within; it is likewise found in round pieces variously contorted. This gum is easily soluble in water, and forms a transparent jelly called mucilage. It is much used in the arts and in medicine. It is mild, void of smell or taste, very well adapted to serve as the basis of pastils, and other preparations used as mitigating or softening remedies.

3. Gum adragant.—The gum adragant is nearly of the same nature as gum arabic. It flows

flows from the adragant of Crete, a small shrub not-exceeding three feet in height. It comes to us in small white tears, contorted, and resembling little worms. It forms with water a thicker jelly than gum arabic, and may be used for the same purposes.

If the roots of marshmallows or of the consolida, linseed, the kernels of the wild quince, (coing), &c. be macerated in water for a time; they afford a mucilage similar to that of gum arabic.

All these gums afford, by distillation, water, an acid, a small quantity of oil, a small quantity of ammoniac or volatile alkali, and much coal. This sketch of analysis proves that mucilage is composed only of water, oil, acid, carbone, and earth; and shews that the various principles of the alimentary juices, such as water, the carbonic acid, and nitrogene gas, are scarcely changed in this substance.

Gums are used in the arts and in medicine. In the arts they are applied to give a greater degree of consistence to certain colours, and to fix them more permanently upon paper; they are also used as a preparation to give a firmer body to hats, ribbons, taffetas, &c. Stuffs dipped in gum water acquire a lustre and brightness; but water, and the handling of these goods,

goods, soon destroy the illusion; and these processes are classed among those which nearly approach to imposition and deceit. Gum is likewise the basis of most kinds of blacking used for shoes, boots, and the like.

The gums are ordered in medicine as emollients. They compose the basis of many remedies of this kind. The mucilage of linseed, or of the kernels of wild quinces, is of value in allaying inflammations.

ARTICLE II.

Concerning Oils.

By common consent the name of Oil is given to fat unctuous substances, more or less fluid, insoluble in water, and combustible.

These products appear to belong exclusively to animals and vegetables. The mineral kingdom exhibits only a few substances of this nature, which possess scarcely any of the above properties, such as the unctuous property.

Oils are distinguished, relative to their fixity, into fat oils, and essential oils. We shall describe them in this article under the names of Fixed Oils and Volatile Oils. The difference between these two kinds of oils does not merely

merely consist in their various degrees of volatility, but also in their habitudes with the several re-agents. The fixed oils are insoluble in alcohol, but the volatile oils are easily dissolved: the fixed oils are in general mild; while the volatile are acrid, and even caustic.

It appears nevertheless that the oily principle is the same in both; but it is combined with mucilage in the fixed oils, and with the spiritus rector, or aroma, in the volatile oils. By burning the mucilage of fixed oils by distillation, they become more and more attenuated; the same may likewise be done by means of water, which dissolves this principle. By distilling volatile oil with a small quantity of water, by the gentle heat of a water bath, the aroma is separated; and this may be again restored by re-distilling it with the odorant plant which originally afforded it.

Volatile oil is usually found in the most odorant part of any plant. In umbelliferous plants it is found in the seed; in the geum, the root affords it; and in the labiated plants it is found in the branches and leaves. The similitude between volatile oils and ether, which appears to be merely a combination of oxygen and alcohol, proves that the volatile oils may be nothing but a combination of the fermentescible

rescible basis of sugar with oxygen. Hence we may form a notion how oil is formed in the distillation of mucilage and of sugar; and we shall no longer be surprised to find that the volatile oils are acrid and corrosive, that they redden blue paper, attack and destroy cork, and approach to the properties of acids. We shall now proceed to treat of fixed and volatile oils separately.

D I V I S I O N I.

Concerning Fixed Oils.

Most of the fixed oils are fluid; but the greater number are capable of passing to the state of solidity, even by a moderate degree of cold. There are some which constantly possess that form in the temperature of our climates; such as the butter of cacao, wax, and the pela of the Chinese. They all congeal at different degrees of cold. Olive oils become solid at 10° below zero of Reaumur; oil of almonds at the same degree; but nut-oil does not freeze in our climates.

The fixed oils possess a very evident degree of unctuousity, do not mix either with water or alcohol, are volatilized at a degree of heat superior to that of boiling water, and when volatilized

tilized they take fire by the contact of an ignited body.

The fixed oils are contained in the kernels of shell fruits or nuts; in the pippins, and sometimes in all the parts of fruits, such as olives and almonds, all whose parts are capable of affording them.

The oil is usually made to flow by expression out of the cellules which contain it; but each species requires a different management.

1. Olive oil is obtained by expression from the fruit of the olive tree. The process used by us is very simple. The olive is crushed by a mill-stone, placed vertically, rolling upon an horizontal plane. The paste thus formed is strongly pressed in a press; and the first oil which comes out is called Virgin Oil. The marc or pulp is then moistened with boiling water; the mass is again pressed; and the oil which floats upon the water carries with it part of the parenchyma of the fruit, and a great part of the mucilage, from which it is difficultly cleared.

The difference in the kind of olive produces a difference in the oil; but the concurrent circumstances likewise establish other differences. If the olive be not sufficiently ripe, the oil is bitter; if it be too ripe, the oil is thick and glutinous.

glutinous. The method of extracting the oil has a very great influence on its quality. The oil mills are not kept sufficiently clean; the mill-stones, and all the utensils, are impregnated with a rancid oil, which cannot but communicate its flavour to the new oil. In some countries it is usual to lay the olives in heaps, and suffer them to ferment before the oil is drawn. By this management the oil is bad; and this process can only be used for oil intended for the lamp or for the soap-boiler.

2. Oil of almonds is extracted from that fruit by expression. For this purpose dry almonds are put into a coarse sack, and agitated rather strongly, to disengage an acrid powder which adheres to the skin. They are then pounded in a marble mortar into a paste, which is wrapped in a coarse cloth, and subjected to the press.

This oil is greenish and turbid when fresh, because the action of the press causes part of the mucilage to pass through the cloth; as it becomes older it is clearer, but is acrid by the decomposition of the same mucilage.

Some persons throw almonds into hot water, or expose them to steam, before they press them; but this addition of water disposes the oils to become rancid more speedily.

By

By this process the oil of all kinds of almonds, nuts, and seeds, may be extracted.

3. Linseed oil is extracted from the seed of the plant *linum*. As this seed contains much mucilage, it is torrefied before it is subjected to the press. This previous treatment gives the oil a disagreeable empyreumatic flavour; but at the same time deprives it of the property of becoming rancid, and renders it one of the most drying oils. All mucilaginous seeds, all kernels and the seeds of henbane and of the poppy, ought to be treated in the same manner.

If a fat oil be distilled in a proper apparatus of vessels, the product is, phlegm; an acid; a fluid or light oil, which becomes thicker towards the end; much hydrogenous gas, mixed with carbonic acid; and a coaly residue, which affords no alkali. I have observed that the volatile oils afford more hydrogenous gas, and the fixed more carbonic acid: this last product depends on the mucilage. By distilling the same oil repeatedly, it is more and more attenuated, becomes very limpid and very volatile, with the only difference that it has acquired the peculiar odour communicated by the fire. The volatilization of the oil may be accelerated by distilling it from an argillaceous earth; by this means it is in a short time deprived of its colouring

louring part : and the heavy oils which afford bitumens, when distilled once or twice from clay alone, such as that of Murviel, are rendered perfectly colourless. The ancient chemists prepared their *oleum philosophorum* by distilling oil from a brick previously impregnated with it.

1. Oil easily combines with oxigene. This combination is either slow or rapid. In the first case, rancidity is the consequence; in the second, inflammation.

Fixed oil exposed for a certain time to the open air, absorbs the oxigenous gas, and acquires a peculiar odour of fire, an acrid and burnt taste, at the same time that it becomes thick and coloured. If oil be put in contact with oxigene in a bottle, it becomes more speedily rancid, and the oxigene is absorbed. Scheele observed the absorption of a portion of the air before the theory was well ascertained. Oil is not subject to alteration in closed vessels.

It seems that oxigene, combined with the mucilage, constitutes rancidity; and that, when combined with the oil itself, it forms drying oil.

The rancidity of oils is therefore an effect analogous to the calcination or oxidation of metals. It essentially depends on the combination of pure air with the extractive principle, which is naturally united with the oily principle.

ciple. We may carry this inference to demonstration, by attending to the processes used to counteract or prevent the rancidity of oils.

A. When olives are prepared for the table, every endeavour is used to deprive them of this principle, which determines their fermentation; and for this purpose various methods are used. In some places they are macerated in boiling water, charged with salt and aromatics; and, after twenty-four hours digestion, they are steeped in clear water, which is renewed till their taste is perfectly mild. Sometimes nothing more is done than to macerate the olives in cold water; but they are frequently macerated in a lixivium of quick-lime and wood ashes, after which they are washed in clear water. But in whatever manner the preparation is made, they are preserved in a pickle charged with some aromatic plant, such as coriander and fennel. Some persons preserve them whole; others split them, for the more complete extraction of their mucilage, and in order that they may be more perfectly impregnated with the aromatics.

All these processes evidently tend to extract the mucilaginous principle, which is soluble in water, and by this means to preserve the fruit from fermentation. When the operation is not well made, the olives ferment and change. If
olives

olives be treated with boiling water, to extract the mucilage, before they are submitted to the press, a fine oil will be obtained, without danger of rancidity.

B. When the oil is made, if it be strongly agitated in water, the mucilaginous principle is disengaged; and the oil may be afterwards preserved for a long time without change. I have preserved oil of the marc of olives, prepared in this manner, for several years, in open bottles, without any alteration.

C. The torrefaction to which several mucilaginous seeds are subjected before the extraction of the oil, renders them less susceptible of change, because the mucilage has been destroyed.

D. M. Sieffert has proposed to ferment oils with apples or pears, in order to deprive rancid oils of their acrimony. By this means they are cleared of the principle which had combined with them, but now becomes attached to other bodies.

Mucilage may therefore be considered as the seed of fermentation.

When the combination of the pure air is favoured by the volatilization of the oil, inflammation and combustion are then the consequence. To carry this combination into effect,

the oil must be volatilized by the application of a heated body; and the flame which is produced is then sufficient to maintain the degree of volatility, and support the combustion. When a current of air is caused to pass through the middle of the wick and the flame, the great quantity of oxygen which must then necessarily pass, occasions a more rapid combustion. Hence it is that the light is stronger, and without smoke: for this is destroyed and consumed by the violent heat which is excited.

The lamps of Palmer are likewise entitled to our particular attention. By causing the rays to pass through a liquor coloured blue, he perfectly imitates the light of the day, which proves that the artificial rays require to be mixed with the blue, to imitate the natural: and the solar rays which pass through the atmosphere, may owe their colour to their combination with the blue colour which appears to predominate in the air.

If water be projected upon oil in a state of inflammation, it is known that extinction does not happen, because the water is decomposed in this experiment. If the product of the combustion of oil be collected, much water is obtained, because the combination of its hydrogen with oxygen produces that fluid.

Mr.

Mr. Lavoisier has proved that one pound of olive oil contains,

Coal or carbone, 12 ounces, 5 gros, 5 grains;

Hydrogene, - 3 — 2 — 67.

The art of rendering oils drying, likewise depends on the combination of oxigene with the oil itself. For this purpose, nothing more is required than to boil it with oxides. If an oil be heated upon the red oxide of mercury, a considerable ebullition ensues, the mercury is reduced, and the oil becomes very drying: this is an observation of Mr. Puymaurin. The oxides of lead or copper are commonly used for this purpose. An exchange of principles takes place in this operation; the mucilage combines with the metal, while the oxigene unites with the oil.

Oil may likewise be combined with the metallic oxides by double affinity, after the manner of Berthollet. For this purpose a solution of soap is poured into a metallic solution. By this means a soap of a green colour is prepared with a sulphate of copper; and, with that of iron, a soap of a deep brown colour, of considerable intensity.

It appears that, in the combination of fixed oils with the oxides of lead, a substance is disengaged, and swims at the top, which Scheele

called the Sweet Principle, and seems to be simply mucilage.

Oil combines with sugar, and affords a kind of soap, which may be easily diffused in water, and kept suspended. The trituration of almonds with sugar and water, forms the *lac amygdale*, *orgeat*, and other emulsions. Combinations of this kind exist ready formed in the vegetable kingdom.

3. Oil unites readily with alkalis; and the result of this union is the well-known compound, soap. To this effect, pot-ash or pure alkali may be triturated with oil, and the mixture concentrated by fire. The medicinal soap is made with oil of sweet almonds, and half its weight of pot-ash or caustic alkali. The soap becomes hard by standing.

To make the soap of commerce, one part of good soda of Alicant must be boiled with two of quicklime, in a sufficient quantity of water. The liquor is then to be strained through a cloth, and evaporated to that degree, that a phial which contains eight ounces of pure water, may hold eleven of the saline solution, which is usually called Soap Lye or Lees. One part of this lixivium, and two of oil, boiled together, till upon trial with a spatula it easily separates, and soon coagulates, form soap.

In

In most manufactories the lixivium is prepared without heat. Equal volumes of pounded soda of Alicant, and quicklime previously flaked, are mixed together. Water is thrown on this mixture, which filters through, and is conveyed into a proper vessel. Water is poured on till it passes through without acquiring any more salt. In this way these kinds of lyes are obtained, which differ in strength; that which passes first is the strongest, and the last is almost mere water. These are afterwards mixed with oil in boilers, where the mixture is favoured by heat. The weak lye is first added, and afterwards gradually the stronger; and the strongest is not added till towards the end of the process.

To make the soap marbled, they make use of soda in the mass, blue copperas, cinnabar, &c. according to the colour desired.

A liquid green or black soap is likewise made by boiling the lixivium of soda, pot-ash, or even wood-ashes, with the marc of the oils of olive, of nuts, or of nape; or with fat, or fish oil, &c. The black soap is made in Picardy, and the green in Holland. The Marquis de Bouillon has proposed to make soaps with animal fat.

At Aniane, and in the neighbourhood of Montpellier, a soft soap is prepared with a caustic

caustic lixivium of wood-ashes, and the oil of the marc of olives.

If soap be exposed to distillation, the result is water, oil, and much ammoniac; and there remains in the retort a large quantity of the alkali used in the fabrication of the soap. The ammoniac which is produced in this experiment, appears to me to arise from the combination of the hydrogenous gas of the oil with the nitrogen, a constituent principle of the fixed alkali.

Soap is soluble in pure water; but it forms curds, and is decomposed in water abounding with sulphates: because the sulphuric acid seizes the alkali of the soap; while the earth combines with the oil, and forms a soap which swims at the surface.

Soap is likewise soluble in alcohol by the assistance of a gentle heat; and forms the essence of soap, or opodeldoc, which may be scented at pleasure.

Soaps are capable of combining with a larger quantity of oil, and rendering it soluble in water. Hence their property of cleansing cloths, linens, &c. They are used as deobstruents in medicine.

4. The fixed oils unite likewise with acids. Messrs. Achard, Cornette, and Macquer, have attended to these combinations. Achard gradually

dually adds the concentrated sulphuric acid to the fixed oil; the mixture being triturated, a mass is obtained which is soluble in water and in alcohol.

The fuming nitric acid immediately turns the fixed oils black, and sets fire to such as are drying. It is in this case decomposed with a rapidity so much the greater, as the oil has a greater affinity with the oxigene. On this account it is that the inflammation of the drying oils is more easily effected than that of the others.

Those acids whose constituent parts adhere most strongly together, have but a very feeble action on oils; a circumstance which proves that the effect of acids upon oils is principally owing to the combination of their oxigene.

It is by virtue of this strong affinity of oils with oxigene, that they possess the power of reviving metals. The oxigene then quits the metal, and unites with the oils, which become thick and coloured. It likewise follows from hence that drying oils ought to be preferred for this use; and we find that practice agrees with theory in this respect.

DIVISION II.

Concerning Volatile Oils.

Fixed oil is combined with mucilage, volatile oil with the spiritus rector, or aroma; and it is this combination or mixture which constitutes the difference between them. The volatile oils are characterized by a strong smell, more or less agreeable; they are soluble in alcohol and have a penetrating and acrid taste. All the aromatic plants contain volatile oil, excepting those whose smell is very transient, such as jafmin, violets, lilies, &c.

The volatile oil is sometimes distributed through the whole plant, as in the Bohemian angelica; sometimes it exists in the bark, as in cinnamon. Balm, mint, and the greater absinthe, contain their oils in the stem and leaves; elicampane, the iris of Florence, and the caryophyllata, in the root. All the resinous trees contain it in their young branches; rosemary, thyme, and wild thyme, contain their essential oils in their leaves and buds; lavender and the rose, in the calyx of their flowers; camomile, lemon, and orange trees, in the petals. Many fruits contain it through their whole substance, such as pepper, juniper, &c. Oranges and lemons

mons in the zest and peeling which inclose them. The seeds of umbelliferous plants, such as anise and fennel, have the vesicles of essential oil arranged along the projecting lines upon their skin: the nutmeg tree contains its essential oil in the nut itself.—See *L'Introduction à l'Etude du Regne Veg. par M. Buquet*, p. 209—212.

The quantity of volatile oil varies according to the state of the plant. Some afford most when green, others when dry; but the latter constitute the smallest number. The quantity likewise varies according to the age of the plant, the soil, the climate, and the time of extraction.

The volatile oils likewise differ in their consistence. Some are very fluid, as those of lavender, rosemary, and rue; the oils of cinnamon and saffrafras are thicker: there are some which constantly preserve their fluidity; others which become concrete by the slightest impression of cold, as those of aniseed and fennel: others again possess the concrete form, such as those of roses, of parsley, and of elicampane.

The volatile oils likewise vary in their colour. The oil of roses is white; that of lavender of a light yellow: that of cinnamon of a brown yellow; the oil of camomile is of a
fine

fine blue; that of millefoil, of a sea-green; that of parsley, green, &c.

The weight is likewise different in the different kinds. The oils of our climates are in general light, and swim upon water; others are nearly of the same weight; and others are heavier, such as the oils of saffrafas and of cloves.

The smells of essential oils vary according to those of the plants which produce them.

The taste of the volatile oils in general is hot; but the taste of the plant does not always influence that of the oil: for example, the oil of pepper has no acrimony, and that which is obtained from wormwood is not bitter.

We are acquainted with two methods of extracting the volatile oils—expression and distillation.

1. Those oils which are, as it were, in a naked state, and contained in projecting and visible receptacles, are obtained by expression. Such are those of citrons, oranges, cedrat, and bergamotte; the oil issues out of the skin of these fruits when pressed. It may therefore be procured by strong pressure of the peeling against an inclined glass. In Provence and in Italy they are rasped; by which means the vesicles are torn, and the oil flows into the vessel destined to receive it: this oil suffers the parenchyma

chyme which goes along with it to subside, and becomes clear by standing.

If a lump of sugar be rubbed against these vesicles, it imbibes the volatile oils; and forms an oleo-saccharum, soluble in water, and very proper to give an aromatic flavour to certain liquids.

2. Distillation is the method most commonly used in the extraction of volatile oils. For this purpose, the plant or fruit which contains the oil is placed in the boiler or body of the alembic. A quantity of water is then poured in, sufficient to cover the plant, and the water is heated to ebullition. The oil which rises with this degree of heat, comes over with the water, and is collected at the surface in a particular receiver, called the Italian receiver, which suffers the surplus of water to escape by a spout issuing from the belly of the vessel, whose orifice is lower than that of the neck of the receiver; so that by this means the oil is collected in the neck, without a possibility of its escaping.

The water which passes over in distillation is more or less charged with oil, and the odorant principle of the plant, and forms what is known by the name of Distilled Water. These waters ought to be returned again into the cucurbit, when the same kind of plant is again distilled; because,

because, being saturated with oil, and the aromatic principle, they contribute to augment the ulterior product.

When the oil is very fluid or very volatile, it is necessary to annex a worm pipe to the alembic, and to have the precaution of keeping the water at a very cold temperature: but when, on the contrary, the oil is thick, the worm pipe must be removed, and the water of the refrigerator kept at a moderate temperature. In the first way, the oils of balm, mint, sage, lavender, camomile, &c. may be distilled; and, by the second, the oils of roses, of elicampagne, of parsley, of fennel, of cumin, &c.

The oil of cloves may likewise be extracted by distillation per descensum; which is determined by applying the fire above the material.

Volatile oils are very subject to be adulterated, either by mixture with fat oils, or with other essential oils, such as that of turpentine, which is cheaper; or by mixing them with alcohol. In the first case the fraud is easily detected—
 1. By distillation, because volatile oils rise at the heat of boiling water. 2. By soaking paper with a spot or trace of the mixture, and exposing it to a degree of heat sufficient to drive off the volatile oil. 3. By means of alcohol, which

which becomes turbid and milky by the insolubility of the fixed oil.

The volatile oils which have a very strong smell, such as those of thyme and lavender, are often sophisticated by oil of turpentine. In this case the fraud may be discovered by soaking a small piece of cotton in the mixture, and leaving it exposed to the air a sufficient time for the smell of the good oil to be dissipated; and leave only that of the adulteration. The same end may be answered by rubbing a small quantity of the mixture on the hand, in which the peculiar smell of oil of turpentine is developed. These oils are likewise falsified by digesting the plant in oil of olive before distillation. In this manner the oil of camomile is prepared.

The very light oils, such as those of cedar or bergamotte, are often mixed with a small quantity of alcohol. This fraud is easily detected by the addition of a few drops of water, which immediately become white, because the alcohol abandons the oil to unite with the water.

The volatile oils are capable of uniting with oxygen, with alkalis, and with acids.

1. Volatile oils absorb oxygen with greater facility than the fixed oils. They become coloured by the absorption, grow thicker, and pass

to

to the state of resin; and when they are thickened to this point, they are no longer capable of fermenting, but secure from all putrefaction such bodies as are penetrated and well impregnated with them. On this is founded the theory of embalming.—The action of acids upon these oils, causes them to pass to the state of resin; and there is no other difference between volatile oil and resin, than that which arises from this addition of oxygen.

All the oils, when they assume the character of resin by this combination of oxygen, let fall needle-formed crystals of camphor. Mr. Geoffroy has observed them in the oil of sewer-few, marjoram, and turpentine. *Acid. 1721, p. 163.*

When the oil is changed by the combination of oxygen, it gradually loses its smell and volatility. To restore this oil to its original state, it is distilled. A thick matter remains in the distilling vessel, which consists of resin perfectly formed, and is thus separated from the oil, which has not yet undergone the same alteration.

2. The habitudes of acids are not the same with all volatile oils. 1. The concentrated sulphuric acid thickens them; but, if it be diluted, it forms savenules. 2. The nitric acid, when

when concentrated, inflames them; but, when diluted, it causes them gradually to pass to the state of resin. Borrichius appears to have been the first who inflamed oil of turpentine with the sulphuric acid, without the nitric acid. Homburg repeated this delicate experiment with the other volatile oils. The inflammation of oils is so much the more easily effected, as the oil is more drying or greedy of oxygen, and the acid more easily decomposed. 3. The muriatic acid reduces oils to the saponaceous state, but the oxygenated muriatic acid thickens them.

3. Starkey appears to have been one of the first who attempted to combine a volatile oil with a fixed alkali. His process is long and complicated, like those of the alchemists; and the combination it afforded was known by the name of Starkey's Soap. The process of this chemist was so long merely because he used the carbonate of pot-ash, or mild vegetable alkali; but if ten parts of caustic alkali, or *lapis causticus*, be triturated hot with eight parts of oil of turpentine, the soap is instantaneously formed, and becomes very hard. This is the process of Mr. Geoffroy.—Acad. des Sciences, ann. 1725.

Concerning

Concerning Camphor.

Camphor is obtained from a species of laurel which grows in China and Japan. Some travellers affirm that the old trees contain it so abundantly, that on splitting the trunk it is found in large tears, so pure as to have no need of rectification. To extract the camphor, the roots of the trees are usually chosen; or, in want of these, all the other parts of the tree. These are put, together with water, into an iron alembic, which is covered with its head. The capital is fitted up internally with cords of rice straw, the joinings are luted, and the distillation proceeded upon. Part of the camphor sublimes, and attaches itself to the straw within the head; while another portion is carried into the receiver with the water. The Hollanders purify camphor by mixing an ounce of quicklime with every pound of the substance, and subliming it in large glass vessels.

Camphor, thus purified, is a white concrete crystalline substance, of a strong smell and taste, soluble in alcohol, burning with a white flame, and leaving no residue: resembling volatile oils in many respects, but differing from them in certain properties; such as that of burning without

out a residue; of dissolving quietly, without decomposition or alteration, in acids; and of being volatilized by a gentle heat, without change of its nature.

Camphor is obtained by distillation from the roots of zedoary, thyme, rosemary, sage, the inula helenium, the anemone, the pasque flower or pulsatilla, &c. And it is to be observed, that all these plants afford a much greater quantity of camphor when the sap has been suffered to pass to the concrete state, by a desiccation of several months. Thyme and peppermint, slowly dried, afford much camphor; whereas the fresh plants afford volatile oil: most of the volatile oils, in passing to the state of resin, also let fall much camphor. Mr. Acharn has likewise observed that a smell of camphor was disengaged when he treated the volatile oil of fennel with acids. The combination of the diluted nitric acid with the volatile oil of anise, afforded him a large quantity of crystals, which possessed most of the properties of camphor. He obtained a similar precipitate by pouring the vegetable alkali upon vinegar saturated with the volatile oil of angelica.

From all these facts it appears, that the base of camphor forms one of the constituent principles of some volatile oils; but it is in the li-

quid state, and does not become concrete but by combining with oxygen.

Camphor is capable of crystallization, according to Mr. Romieu, whether in sublimation, or when it is slowly precipitated from alcohol, or when alcohol is supersaturated with it; it precipitates in slender filaments, crystallizes in hexagonal blades attached to a common axis, and it sublimates in hexagonal pyramids or in polygonal crystals.

Camphor is not soluble in water; but it communicates its smell to that fluid, and burns on its surface. Romieu has observed that small pieces of camphor, of one-third or one-fourth of a line in diameter, being placed on the surface of pure water in a glass, have a rotatory motion; and this appears to be an electrical phenomenon; for the motion ceases if the water be touched with a conducting substance, but continues if it be touched with an insulating body, such as glass, sulphur, or resin. Bergen has observed that camphor does not turn upon hot water.

Acids dissolve camphor without producing any alteration in it, or becoming themselves decomposed; the nitric acid dissolves it quietly; and this solution has been called Oil of Camphor. Camphor precipitated from its solution

acids by the addition of alkalis, is heavier, harder, and much less combustible, according to the experiments of Mr. Kofegarten. By distilling the nitric acid several times from this substance, it acquires all the properties of an acid which crystallizes in parallelopipedons. To obtain the camphoric acid; nothing more is required than to distil the acid at several times from the camphor, and in a large quantity. Mr. Kofegarten distilled the nitric acid eight times from camphor, and obtained a salt crystallized in parallelopipedons; which reddened syrup of violets, and the tincture of turnsole. Its taste is bitter; and it differs from the oxalic acid in not precipitating lime from the muriatic acid.

With potash it forms a salt which crystallizes in regular hexagons.

With soda it affords irregular crystals.

With ammoniac it forms crystalline masses, which exhibit crystals in needles and in prisms.

With magnesia it produces a white pulverulent salt, which may again be dissolved in water.

It dissolves copper, iron, bismuth, zinc, arsenic, and cobalt. The solution of iron affords a yellowish white powder, which is insoluble.

This acid forms, with manganese, crystals whose planes are parallel, and in some respects resemble barites.

The camphoric acid, or rather the radical of this acid, exists in several vegetables; since camphor may be extracted from the oils of thyme, of cinnamon, of turpentine, of mint, of feverfew, of saffraſas, &c. Mr. Dehne has obtained it from the paſque flower, or pulſatilla; and Cartheuſer has indicated ſeveral other plants which contain it.

Alcohol readily diſſolves it, and it may be precipitated by water alone: this ſolution is known in pharmacy by the name of Camphorated Spirit of Wine; or Camphorated Brandy, when brandy is the ſolvent.

The fixed and volatile oils likewiſe diſſolve each other by the aſſiſtance of heat; the ſolutions let fall cryſtals in vegetation, ſimilar to thoſe which are formed in the ſolutions of ſal ammoniac, compoſed of very fine filaments adhering to a middle part. This obſervation was made by Mr. Romieu, Acad. des Sciences, 1756.

Camphor is one of the beſt remedies which the art of medicine poſſeſſes. When applied to inflammatory tumours it is reſolvent; and, internally taken, it is antipſmodic, eſpecially when diſſolved in brandy. It is given in Germany and in England in the doſe of ſeveral drams per day; but in France our timid phyſicians do not preſcribe it in a larger doſe than
a few

a few grains. It mitigates heat in the urinary passage. It is given triturated with yolk of egg, sugar, &c.

It has likewise been supposed that its smell destroyed or drove away moths, and other insects, which feed upon cloth, &c.

A R T I C L E III.

Concerning Refins.

The name of Refin is used to denote inflammable substances soluble in alcohol, usually affording much soot by their combustion; they are likewise soluble in oil, but not all in water.

All the refins appear to be nothing else but oils rendered concrete by their combination with oxigene. The exposure of these to the open air, and the decomposition of acids applied to them, evidently prove this conclusion.

Refins in general are less sweet than the balsams. They afford more volatile oil, but no acid, by distillation.

There are some among the known refins which are very pure, and perfectly soluble in alcohol, such as the balm of Mecca and of Copahu, turpentine, tacamahaca, elemi; others are less pure, and contain a small portion of
extract,

extract, which renders them not totally soluble in alcohol; such are mastic, sandarach, guaiacum, laudanum, and dragon's blood.

1. The balsam of Mecca is a fluid juice which becomes thick and brown by age. It flows from incisions made in the *amaris opobalsamum*. It is known by the different names of Balm of Judea, of Egypt, of Grand Cairo, of Syria, of Constantinople, &c.

Its smell is strong, and inclining to that of lemons; its taste is bitter and aromatic.

This balsam, distilled by the heat of boiling water, affords much volatile oil.

It is balsamic; and is given incorporated with sugar, or mixed with the yolk of egg. It is aromatic, vulnerary, and healing.

2. The balsam of Copahu flows from a tree called Copaiba, in South America, near Tolu. It affords the same products, and possesses the same virtues, as the foregoing.

3. The turpentine of Chios flows from the turpentine tree, which affords the pistachios. It is fluid, and of a yellowish white colour inclining to blue.

This plant grows in Cyprus, at Chios, and is common in the south of France. The turpentine is obtained only from the trunk and large branches. Incisions are made first at the lower

lower part of the tree, and afterwards by degrees, higher up.

This turpentine, distilled on the water-bath, without addition, affords a very white, very limpid, and very fragrant volatile oil: a more ponderous oil may be extracted at the heat of boiling water; and the residue, which is called Boiled Turpentine, affords by distillation, in the reverberatory furnace, a weak acid, a small quantity of brown consistent oil, and much coal.

The turpentine of Chios is very rare in commerce. Venice turpentine is extracted from the *larix*: its colour is a bright yellow; its consistence limpid, its smell strong and aromatic, and its taste bitter.

The tree which affords it is that which affords manna. Holes are bored during the summer, near the bottom of the trunks of these trees, into which small gutters or tubes are inserted, to convey the juice into vessels intended to receive it. The resin is obtained only from trees in full vigour; the old trees very often have considerable depositions of resin in their trunks.

This turpentine affords the same principles as that of Chios.

It is used in medicine as a detergent for ulcers in the lungs, kidneys, &c. either incorporated with sugar, or mixed with the yolk

yolk of an egg, to render it more miscible with aqueous potions. The soap of Starkey, which we have spoken of under the article of Volatile Oils, is made with this turpentine.

The resin known in commerce by the name of Strasburgh Turpentine, is a resinous juice of the consistence of a fixed oil, of a yellowish white colour, a bitter taste, and a more agreeable smell than the preceding resins.

It flows from the yew-leaved fir, which is very common in the mountains of Switzerland. This resin is collected in blisters, which appear beneath the bark in the strong heats of summer. The peasants pierce these vesicles with the point of a small horn, which becomes filled with the juice, and is from time to time emptied into a larger vessel.

The balm of Canada differs from the turpentine of the fir in its smell only, which is more pleasant. It is obtained from a species of fir which grows in Canada.

Oil of turpentine is more particularly used in the arts. It is the great solvent for all resins; and, as it evaporates, it leaves them applied to the surface of bodies on which the mixture has been spread. As resins are the basis of all varnishes, alcohol and oil of turpentine must be the vehicles or solvents.

4. Pitch is a resinous juice, of a yellow colour, more or less inclining to brown. It is afforded by a fir named *Picea* or *Epicea*. Incisions are made through the bark; and the wound is renewed from time to time, as the lips become callous. A vigorous tree often affords forty pounds.

Pitch melted, and expressed through bags of cloth, is rendered purer. It is packed in barrels, by the name of White Pitch, or Burgundy Pitch.

White pitch, mixed with lamp-black, forms black pitch.

White pitch kept in fusion becomes dry. The desiccation may be facilitated with vinegar, and leaving it for a time over the fire. It then becomes very dry, and is called Colophony.

Lamp-black is the foot of burned pitch. It is likewise prepared by collecting the foot of pit-coal.

5. Galipot is a concrete resinous juice, of a yellowish white colour and strong smell. This juice comes from Guienne, where it is afforded by two species of pine, the *pinus maritima major*, et *minor*.

When these trees have acquired a certain size, a hole or notch is cut through the bark, near the bottom of the trunk. The resin issues out, and flows into vessels placed beneath to receive it.

it. Garg is taken to keep the wound open, and to renew it. The resin flows during the summer; but that which issues out during the spring, autumn, and winter, dries against the tree.

The pine likewise affords tar, and the oil called *huile de Gade*. For this purpose the wood of the trunk, branches, and roots, is heaped together and covered with turf, over which a fire is lighted, as if to convert them into charcoal. The oil which is disengaged, not being at liberty to escape, falls to the bottom into a channel or gutter, which conveys it into a tub. The most fluid part is sold under the name of *huile de Gade*; and the thicker part is the tar used for paying or painting the parts of shipping and other vessels.

The combination of several resins, coloured by cinnabar and minium, forms sealing-wax. To make the wax, take half an ounce of gum-lac, two drams of turpentine, the same quantity of colophony, one dram of cinnabar, and the same quantity of minium. The lac and the colophony are to be first fused, after which the turpentine is to be added, and lastly the colouring matters.

6. Mastic has the form of white tears of a farinaceous appearance, having little smell, and a bitter astringent taste. Mastic flows naturally from

from the tree, but its produce is accelerated by incisions. The lesser turpentine tree, and the lentiscus, afford that which is met with in commerce.

Mastic affords no volatile oil when distilled with water. It is almost totally soluble in alcohol.

This resin is used in fumigations. It is chewed, to strengthen the gums; and it forms the basis of several drying varnishes.

7. Sandarach is a concrete resinous juice, in dry white transparent tears, of a bitter and astringent taste. It is obtained from most species of the juniper, and is found between the bark and the wood.

Sandarach is almost totally soluble in alcohol, with which it forms a very white varnish, that dries speedily. For this reason, the resin itself is known by us, under the name of Varnish (*vernis*).

8. Labdanum is a black resinous juice, dry and friable, of a strong smell, and a disagreeable aromatic taste. It transudes from the leaves and branches of a kind of cistus, which grows in the island of Candia. Tournefort, in his Voyage to the Levant, informs us, that when the air is dry, and the resin issues out of the pores of the cistus, the peasants strike all the parts

parts of these trees with a kind of whip, made of several thongs of leather, fixed to the end of a staff. The juice adheres to the leather, and is cleared off with a knife. This is pure labdanum, and is very rare. That which is known by the name of *labdanum in tortis*, is mixed with a very fine ferruginous sand, for the purpose of increasing its weight.

9. Dragon's blood is a resin of a deep red in the mass, but brighter when in powder. It has neither taste nor smell.

It is obtained from the *drakena*, in the Canary islands, from which it flows in tears during the dog-days. It is also obtained from the *ptero-carpus draco*. The parts are exposed to the vapour of hot water; the juice issues out in drops, which are collected and wrapped up in the leaves of reeds.

The dragon's blood of the shops, which has the form of flattened orbicular loaves, is a composition of various gums, to which this form is given, after they have been coloured with a small quantity of dragon's blood.

Dragon's blood is soluble in alcohol: the solution is red: the resin itself may be precipitated of the same colour.

This resin is used in medicine as an astringent.

ARTICLE IV.

Concerning Balsams.

Some authors define balsams to be fluid inflammable substances; but there are some which are dry. Others again give this name to the most fragrant among the resins. M. Bucquet has confined this denomination to such resins only as have a sweet flavour, capable of being communicated to water; and which more especially contain fragrant acid and concrete salts, which may be separated by decoction or sublimation. It appears therefore that these substances contain a principle not found in resins, which, combining with oxigene, forms an acid; while the oil, saturated with the same air, forms the resin. This acid salt is soluble in water and alcohol. As the chemical analysis points out a sufficiently striking difference between balsams and resins, we think it proper to treat them separately.

The substances called Balsams are therefore resins united with a concrete acid salt. We are acquainted with three principal kinds; viz. benzoin, the balsam of Tolu, and the storax calamita.

1. Benzoin

1. Benzoin is a coagulated juice, of a pleasant fragrant smell, which becomes stronger by friction and heat.

Two varieties of this substance are known; the benzoë amygdaloides, and the common benzoin. The first is composed of the most beautiful tears of this balsam, connected together by a gluten of the same nature, but browner, and of the aspect of nutmegs in its fracture. The second is merely the juice itself, without any mixture of these fine and very pure tears. It comes to us from the kingdom of Siam, and the island of Sumatra; but we do not know the tree that affords it *.

Benzoin, laid upon hot coals, fuses, & speedily takes fire, and emits a strong aromatic smell. But if it be merely heated, without setting it on fire, it swells up, and emits a more pleasant though less powerful smell.

Benzoin pounded, and boiled in water, affords an acid salt; which crystallizes in long needles by cooling. This salt may also be extracted by sublimation. It rises by a degree of heat even less than that which is required to raise the oil of benzoin; and this is the substance called Flowers of Benzoin, or the Sublimed Acid of Benzoin.

* For a drawing and description of this tree, consult Dryander, in the Phil. Transf. vol. lxxviii. No. 31.

zoin. Neither of these processes is oedonoma-
cal; and in the preparation of these articles, in
the large way, I begin by distilling the benzoïn,
and cause all the products to pass confounded
together into a capacious receiver. I then
boil the product in water, and by this means
I obtain a much greater quantity of the salt of
benzoïn. Because, in this state, the water at-
tacks and dissolves the whole contents; where-
as the most accurate trituration will not pro-
duce the same effect.

The sublimed acid of benzoïn has a very pe-
netrating aromatic smell, which excites cough-
ing; more especially if the subliming vessels be
opened while yet hot. It reddens the syrup of
violets, and effervesces with the alkaline carbo-
nates. It unites with earths, alkalis, and me-
tals, and forms benzoates, of which Bergmann
and Scheele have given us some account.

Alcohol dissolves benzoïn totally, without
leaving any residue but such foreign impurities
as the balsam may happen to contain. It may
be precipitated by the addition of water; and
then constitutes the opaque fluid called *Lac Vir-
ginale*.

Benzoïn is used as an aromatic in medicine;
but it is seldom used in substance, because of its
sparingly solubility: its tincture, and volatile acid;
are

are used. The latter is a good incisive medicine to be administered in pituitous obstructions of the lungs, the kidneys, &c. It is given in extracts, or dissolved in water.

Benzoin is employed in fumigations for indolent tumours. The oil is likewise an excellent resolvent. It is applied by friction to members affected with cold rheumatic and paralytic disorders.

3. The balsam of Tolu, of Peru, or of Carthagena, has a mild and pleasant smell.

It is met with in commerce in two different forms; either in shells; or in the fluid state. The coco is softened by boiling water, and the balsam flows out in the fluid form.

The tree which affords it, is the *Toluisera* of Linnaeus. It grows in South America, in the district called Tolu, between Carthagena and Nombre de Dios.

The fluid balsam affords much volatile oil when distilled by the heat of boiling water.

An acid salt may be extracted from this balsam, which greatly resembles that of benzoin, and may be obtained by the same processes; but this sublimed salt is commonly brown, because it is soiled by a portion of the balsam, which rises with a less heat than benzoin does.

This

This balsam is soluble in alcohol, and may be precipitated by the addition of water.

It is much used in medicine, as an aromatic, vulnerary, and antiputrescent remedy. It is administered either triturated with sugar, or mixed with some extract. A syrup is prepared from it by digesting it in a gentle heat with sugar; or by dissolving it in alcohol, adding sugar, and suffering the alcohol to dissipate spontaneously.

It is falsified by macerating the distilled oil of benzoin upon the buds of the balm-scented poplar, and adding a small quantity of the natural balsam.

Storax or *styrax calamita* is a juice of a very strong but very pleasant smell. Two varieties are known in commerce: the one in reddish clean tears, the other in masses of a blackish red colour, soft and fatty.

The plant which affords it is called the oriental liquid amber. It has been long supposed to be the *styrax folio mali cotonæi* C. B. which is known in Provence, in the wood of La Chartreuse de Montrieu, by the name of *Aliboussier*; and, according to Duhamel, affords a very odorous juice, which he took for storax.

Its habitudes during analysis are the same as the preceding, and it exhibits the same phenomena.

It was formerly brought to us in canes or reeds; whence its name of storax calamita.

These three balsams form the base of those fragrant pastils which are burned in the chambers of the sick, to conceal or disguise bad smells. These balsams are made into masses by means of gum; with the addition of charcoal and the nitrate of pot-ash, to facilitate combustion.

ARTICLE VI.

Concerning Gum Resins.

The gum resins are a natural mixture of extract and resin. They seldom flow naturally from plants, but issue out from incisions made for that purpose. They are sometimes white, as in the tithymalus and the fig-tree; sometimes yellow, as in the chelidonium; so that we may consider these substances as true emulsions, whose constituent principles vary in their proportions.

The gum resins are partly soluble in water, and partly in alcohol.

One character of gum resins is, that they render water turbid in which they are boiled.

This class is sufficiently numerous; but we shall only treat of the principal species, and more

more especially those which are used in medicine.

Olibanum, or frankincense, is a gum resin, in tears of a yellowish white colour, and transparent. Two kinds are known in trade: the male incense, in small very pure tears; and the female incense, in large and impure tears.

The tree which affords it is not known. Some authors suppose it to be the cedar with cypress leaves.

Olibanum contains three parts of resinous matter, and one of extract. When it is boiled in water, the solution is white and turbid, like that of all the juices of this class. When it is fresh, it affords a small quantity of volatile oil.

Olibanum is used in medicine as a resolvent, But its chief use is in our temples, where it has been adopted as one of the instruments of worship of the Divinity.

It is used in hospitals, to disguise the smell of the putrid air which is exhaled. M. Achard has proved that this proceeding has no other effect than that of deceiving the sense of smelling.

1. *Scammony* is of a blackish grey colour, a bitter and acrid taste, and a strong nauseous smell.

Two varieties are met with in commerce; one of which comes from Aleppo, and the other from Smyrna. The first is paler, lighter,

and more pure; the second is black, heavy, and mixed with foreign substances.

It is extracted from the convolvulus scammonia, principally from the root. For this purpose incisions are made at the head of the root; it is collected in muscle shells. But most of that met with in trade is obtained from the roots by expression.

From the results of the analysis of Geoffroy and Cartheuser, it appears that the proportion of the component parts varies in the different specimens examined. The latter obtained near one-half of extract, whereas the former found only one-sixth.

Scammony is used in medicine as a purgative, in the dose of several grains. When triturated with sugar and almonds, it forms a very agreeable purgative emulsion. When softened by a mixture of the juice of liquorice, or of wild quinces, it forms the diagredium.

3. Gum guttæ has a reddish yellow colour: it has no smell; but its taste is acrid and caustic. Gum guttæ was brought to Clusius in 1630. It comes from the kingdom of Siam, from China, and from the island of Ceylon, in cylinders of various sizes. The tree which affords it is called Coddam Pulli. Herman reports, from his own observation as an eye-witness, that a milky and yellowish juice flows from incisions made

made in these trees; that this juice becomes thick by the heat of the sun; and that, when it is in a state fit to be handled, it is formed into large globular masses.

Geoffroy has extracted five-sixths of resin from gum guttæ. Cartheuser has ascribed to it more extractive than resinous matter.

Gum guttæ is sometimes used as a purgative, in a dose of a few grains. But the principal use of this substance is in painting, where it is recommended by the beauty of its colour.

4. *Affa fœtida* is met with in tears of a yellowish white colour; but most commonly in the form of loaves formed by the aggregation of a number of the tears. It has an acrid and bitter taste, and its smell is one of the most disagreeable.

The plant which affords it is called *Ferula Affa Fœtida*.

This plant grows in Persia; and the juice of its root is obtained by expression, according to Kæmpfer. It is fluid and white when it issues from the plant, and it emits an abominable smell when recent. This juice loses its smell, and becomes coloured, as it dries. But it still retains smell enough to entitle it to the name of *Stercus Diaboli*.

The Indians find its flavour agreeable; they use it for seasoning, and call it the *food of the gods*:

golds: a proof which evinces, beyond every argument, that tastes must not be disputed.

Cartheuser found it to contain one-third of resin.

It is a solvent and discutient remedy; and more particularly valuable as a most powerful antihysteric.

5. Aloes is a juice of a red brown colour, and very considerable bitterness. Three species are distinguished—the soccotrine aloes, the hepatic aloes, and the coballine aloes: they differ only in their degree of purity. M. de Jussieu, who saw these three varieties prepared at Morviedro in Spain, assures us that they are all obtained from the *aloë vulgaris*. The first variety is obtained by making incisions in the leaves. Time is allowed for its impurities to subside perfectly. The fluid is then decanted from the dregs, and left to become thick; after which it is put into leathern sacks for sale, under the name of Soccotrine aloes. A juice of the same nature is obtained by expression from the same leaves, which, when clarified in the same manner, forms the hepatic aloes; and the coballine aloes is obtained by a stronger pressure.

The Soccotrine aloes contains no more than one-eighth of resin, according to Boulduc. The hepatic aloes contains half its weight.

Aloes

Aloe is very much used in medicine as a purgative, tonic, alterative, and vermifuge.

6. Gum ammoniac is sometimes met with in small tears, white within, and yellow without. But they are often united in the mass, resembling the benzoe amygdaloides.

Its smell is fetid; and its taste acrid, bitter, and rather nauseous.

This juice comes from the deserts of Africa, and the plant which affords it is unknown: it is presumed to be of the class of umbelliferous plants, from the figure of the seeds found in it.

Gum ammoniac is very much used in medicine. It is a very good alterative, and is given in pills, incorporated with sugar, or in some extract. It may even be dissolved or diffused in water: this liquid becomes turbid, and of a yellowish white. Gum ammoniac enters into the composition of all discutive plasters.

Concerning Caoutchouc, or Elastic Gum.

Elastic gum is one of those substances which it is difficult to class. It burns like resins; but its softness, its elasticity, and its insolubility in the menstrua which usually dissolve resins, do not allow us to class it among those bodies.

The tree which affords it is known by the name

name of Seringa by the Indians of Para. The inhabitants of the province of Esmeraldas, a province of Quito, call it Hhava; and those of the province of Mamas, Caoutchou.

Mr. Richard has proved that this tree is of the family of the euphorbia; and Mr. Dorthes has observed, that the *coccas* which are covered with a down that resembles small straws, were covered with a gum very much resembling the elastic gum. These insects feed on the euphorbium; but those which come from other situations afford the same juice.

We are indebted to Mr. Condamine for an account, and accurate details, concerning this tree.

(Acad. des Sciences, 1751.) This academician informs us, after Mr. Fresneau, engineer at Cayenne, that the caoutchou is a very lofty tree. Incisions are made in the bark; and the white juice, which flows out in a more or less liquid state, is received in a vessel placed for that purpose. This is applied in successive coatings upon a mould of clay, and dried by the fire, or in the sun. All sorts of designs are traced upon it while soft; and, when it is dry, the clay mould is crushed, and the pieces shaken out.

This gum is very elastic, and capable of great extension.

When elastic gum is exposed to the fire, it becomes

becomes soft, swells up, and burns with a white flame. It is used for illumination, instead of candles, at Cayenne.

It is not at all soluble either in water or alcohol. But Macquer has assured us that ether is its true solvent, and upon this property he has instituted the art of making bougies for surgical uses of elastic gum, by applying this solution upon a mould of wax till it is of the requisite thickness.

Mr. Berniard, to whom we are indebted for important observations upon this substance, found only the nitric ether which dissolved elastic gum. Very pure sulphuric ether did not perceptibly act upon it.

If elastic gum be put in contact with a volatile oil, such as that of turpentine, or even if it be exposed to the vapour of that fluid, it swells, softens, and becomes very pasty. It may then be spread upon paper, or applied as a varnish to cloth; but this covering preserves its adhesive quality, and does not lose it for a long time. The mixture of volatile oil and alcohol forms a better solvent than the pure oil, and the varnish dries more speedily.

Mr. Berniard has concluded from his experiments that the elastic gum is a fat oil, coloured by a matter soluble in alcohol, and soiled by the

the smoke to which the gum is exposed in drying.

If linseed oil be rendered very drying by digesting it upon the oxides of lead, and it be afterwards applied with a small brush upon any surface, and dried by the sun or in the smoke, it affords a pellicle of a considerable degree of firmness, evidently transparent, burning like elastic gum, and wonderfully elastic and extensible. If this very drying oil be left in a wide shallow vessel, the surface becomes thick, and forms a membrane which has the greatest analogy with the elastic gum. A pound of this oil spread upon a stone, and exposed to the air for six or seven months, acquired almost all the properties of elastic gum. It was used to make catheters and bougies; was applied to varnish balloons, &c.

Some gum resins are cleared by art of their extractive principle, for the purpose of applying them to various uses. Such is the intention of the process used to make bird-lime. This is made from different substances, as the berries of mistletoe, the fruit of the sébesten, &c. But the best is that which is made of the bark of the hollyoak. These trees are peeled in the month of June or July; the outer bark is rejected, and the second is boiled in spring water
for

for seven or eight hours. It is then made into masses, which are buried in the ground, and covered with stones, for several layers one over the other. After having previously drained off the moisture, they are suffered to ferment for fifteen days, until the matter has acquired the adhesive consistence of paste. The mass is then beaten till it becomes capable of being wrought with the hands, or kneaded; after which it is washed in a running stream. Lastly, it is placed for three or four days in another vessel, that it may throw up its skum or impurities; in which last state it is put into proper vessels, and kept for use.

The following composition is likewise made use of under the name of Bird-Lime. Take one pound of bird-lime, one pound of goose-grease; add to this one ounce of vinegar, half an ounce of oil, and the same quantity of turpentine. Boil the mixture for several minutes, and heat the mass when you are desirous of using it as a cement. It may be prevented from freezing in winter, by adding a small quantity of petroleum.

Concerning Varnish.

The Pere d'Incarville has informed us that the tree which affords the varnish of China is called

called Tsi-chou by the Chinese. This tree is propagated by off-sets. When the cultivator is desirous of planting this, he takes a branch, which he wraps up in a mass of earth, by means of flax. Care is taken to moisten this earth; the branch pushes out roots, and is then pruned and transplanted. This tree grows to the size of a man's leg.

The varnish is drawn in spring. If it be a cultivated tree, it affords three gatherings. It is extracted by incisions made in the spring; and when the varnish, which is received in shells, does not flow, several hogs bristles, moistened with water or spittle, are introduced into the wound, and cause it to run. When the tree is exhausted, the upper part of it is wrapped in straw, which is set on fire, and causes the varnish to precipitate to the bottom of the tree, where it flows out of perforations made for that purpose.

Those who collect the varnish set out before day-break, and place their shells beneath the apertures. The shells are not left longer than three hours in their place, because the heat of the sun would evaporate the varnish.

The varnish emits a smell which the workmen are very careful to avoid respiring. It produces an effect which they call the bud of the Varnish.

When

When the varnish-*resin* from the tree, it resembles pitch. By exposure to the air it gradually becomes coloured, and is at last of a beautiful black.

The juice which flows from incisions made in the trunk and branches of the *thus toxicodendron*, possesses the same properties. The tree that grows in our climate affords a white milky fluid, which becomes black and thick by the contact of the air; its colour is the most beautiful black: and it would be easy to introduce this valuable species of industry into the kingdom, because the tree grows wonderfully well in all climates, and resists the cold of the winter.

To make the varnish bright, it is evaporated by the sun, and a body is given to it with hog's gall, and the sulphate of iron, or martial vitriol.

The Chinese use the oil of tea, which they render drying by boiling it with orpiment, realgar, and arsenic.

The varnishes most used in the arts have all of them the resins for their base; and the fundamental facts in this valuable art are reducible to the following principles.

To varnish any substance, consists in applying upon its surface a covering of such a nature, as shall defend it from the influence of the air, and give it a shining appearance.

A coat

A coat of varnish ought therefore to possess the following properties:—1. It must exclude the action of the air; because wood and metals are varnished to defend them from decay and rust. 2. It must resist water; for otherwise the effect of the varnish could not be permanent. 3. It ought not to alter such colours as are intended to be preserved by this means.

It is necessary therefore that a varnish should be easily extended or spread over the surface, without leaving pores or cavities; that it should not crack or scale; and that it should resist water. Now resins are the only bodies that possess these properties.

Resins consequently must be used as the bases of varnish. The question which of course presents itself must then be, how to dispose them for this use; and for this purpose they must be dissolved, as minutely divided as possible, and combined in such a manner that the imperfections of those which might be disposed to scale, may be corrected by others.

Resins may be dissolved by three agents—
1. By fixed oil. 2. By volatile oil. 3. By alcohol. And accordingly we have three kinds of varnish: the fat or oily varnish, essential varnish, and spirit varnish.

Before a resin is dissolved in a fixed oil, it is
neces-

necessary to render the oil drying. For this purpose the oil is boiled with metallic oxides; in which operation the mucilage of the oil combines with the metal, while the oil itself unites with the oxygen of the oxide. To accelerate the drying of this varnish, it is necessary to add oil of turpentine.

The essential varnishes consist of a solution of resin in oil of turpentine. The varnish being applied, the essential oil flies off, and leaves the resin. This is used only for paintings.

When resins are dissolved in alcohol, the varnish dries very speedily, and is subject to crack; but this fault is corrected by adding a small quantity of turpentine to the mixture, which renders it brighter, and less brittle when dry.

The coloured resins or gums, such as gum guttae, dragon's blood, &c. are used to colour varnishes.

To give lustre to the varnish after it is laid on, it is rubbed with pounded pumice stone and water; which being dried with a cloth, the work is afterwards rubbed with an oiled rag and tripolis. The surface is last of all cleaned with soft linen cloths, cleared of all greasiness with powder of starch, and rubbed bright with the palm of the hand.

ARTICLE VI.
Concerning the Fecula of Vegetables.

The fecula appears to be only a slight alteration of mucilage; for it differs from that substance in no other respect than in being insoluble in cold water, in which liquid it falls with wonderful quickness. If it be put into hot water, it forms a mucilage, and resumes all its characters. It seems that the fecula is simply a mucilage deprived of caloric. In fact, a young plant is all mucilage; the old plants and fruits afford little fecula, because their heat is stronger in young than in old plants; according to Dr. Hunter.

There are few plants which do not contain fecula. Mr. Parmentier has given us a list of all those which afford it, in his experiments. (See his *Recherches sur les Végétaux Nourissans*.) But the seeds of gramineous and leguminous vegetables, as well as the roots, which botanists call *Tuberoses*, contain it most plentifully. Nothing more is required, in order to extract the fecula, than to bruise or grind the plant in water; and the fecula, which is at first suspended in that fluid, soon falls to the bottom. We shall

not

not in this place attend to any other feculæ but such as are used in the arts or in medicine. Such are those of bryony, of potatoes, cassava, sago, salep, starch, &c.

1. The fecula of bryony is extracted from the root of that plant. The bark is first taken off from the roots, which is then rasped, and submitted to the press. The juice which flows out by expression is rendered white and opake by a fecula which subsides. The liquid is then decanted off, and the fecula dried. It is strongly purgative, on account of a portion of extract which it retains; but it may be deprived of its purgative virtue by careful washing in water. If water be poured on the marc which remains beneath the press, a large quantity is obtained which is not purgative, because the extractive matter was forced out by the first operation. Mr. Baumé has proposed to substitute this fecula instead of starch. The fecula is afforded by similar treatment of the roots of corn-flag and arum.

2. That which is generally known by the name of Potatoe Flour, is nothing but the fecula of this root obtained by ordinary and easy processes. The root being well washed, it is pounded or crushed in such a manner as perfectly to destroy its texture. The pulp is then

put into a sieve, and water poured on it, which carries off the fecula, and deposits it at the bottom of the receiving vessel. The water, which is coloured by extractive matter, and part of the parenchyma that remains suspended, is decanted off, and the deposition is washed several times. The colour of the fecula grows whiter as it dries; and when dry it is very white and fine.

As this fecula has become an article of common use for some time past, several instruments have been contrived which are more or less suited to bruise the potatoes. Rasps have been proposed turning in cylinders, mills armed with points of iron, &c.

3. The cassava of the Americans is extracted from the roots of the manioc. This plant contains an acrid and very dangerous poison, of which it must be very carefully deprived. The Americans take the fresh root of manioc, which they peel, rasp, and inclose in a bag or sack formed of rushes, and of a very open texture. This bag is suspended from a staff; and a very heavy vessel is fastened to its lower part, which draws the bag down, so as, in some measure to compress the root, at the same time that it receives the juice as it flows out. The juice is a most dreadful poison. When the root is well

well cleared of the juico, it is put into the same bags, and exposed to dry in the smoke. The fifted root is called Cassava. To convert it into food, it is spread out upon an hot brick or plate of iron; and when the surface which rests immediately on the brick is of a reddish brown colour, it is turned, to bake the other side; and in this state it forms what is called Cassava Bread.

The expressed juice carries with it the finest part of the fecula, which quickly subsides; and this fecula, known by the name of Mouchasse, is used to make pastry.

The poisonous extract which most of these roots that abound in fecula contain, ought to engage those who prepare them to be uncommonly attentive to the due management of the process. Without the most scrupulous care the most unhappy consequences may follow. It should always be recollected, in the preparation of these substances, that the poison is in contact with the food.

A fecula has likewise been appropriated to domestic uses, which is extracted from the pith of several farinaceous palms, and is known by the name of Sago. This preparation is made in the Molucca Islands. The pith of middle-aged palms is only used; for the young, as well as the old, afford very little fecula. This pith

is mixed with water; and the fecula which is extracted, and renders the fluid white, is suffered to subside. When the fecula is dried, it forms small grains; which when reduced to powder, and mixed with warm water, afford a very nourishing pulp or mucilage.

M. Parmentier has proposed to make sago out of potatoes; in consequence of his idea that all feculæ are absolutely identical, and that this principle is one and the same in nature. For this purpose he proposes to add a spoonful of the fecula of potatoes gradually to a chopin, or half a pint, of hot water or milk, to be kept stirring over a gentle fire for half an hour. Sugar may be added, with aromatics or spices, such as cinnamon, lemon peel, saffron, orange-flower water, rose-water, &c.

The sago of potatoes may likewise be prepared with veal broth, chicken broth, or common broth. The preparation may be varied in a thousand ways, and it forms a very wholesome and nourishing food.

5. The bulbs of all the kinds of orchis may be used to make salep. All that is required to be done consists in depriving them of the extractive principle, and drying the residue, which becomes transparent by this operation.

In order to dry them more speedily, they are strung, and hung up; or otherwise it is thought

suffi-

sufficient to rub these bulbs in water either hot or cold, and to dry them in an oven. This last process was communicated to Dr. Percival by Mr. John Moulton.

The fecula of salep, pulverized, and combined with water, forms a very nourishing jelly.

6. The fecula is likewise one of the constituent principles of the seeds of gramineous plants; and when these have been ground, and reduced into farina, nothing more is required than to mix them with water, in order to precipitate the fecula. But another process for procuring it is used in the arts: it consists in destroying by fermentation the extractive and glutinous part with which it is intimately united; and in this consists the art of making starch. The process of the starch-maker consists in fermenting grain, pollard, damaged flour, &c. in the acid water which they call *eau sure*. When the fermentation is ended, they take out the fecula, which is precipitated to the bottom of the water, and put it into hair sacks. Fresh water is poured upon this, which carries the finer fecula with it; and this being several times washed, constitutes starch, cleared of every foreign principle.

There are likewise coloured feculæ, such as indigo, which we shall treat of, when we come to the article Dyeing.

The

The uses of the feculæ are very numerous.

1. They constitute a very nourishing food, because the nutritive virtue of gramineous vegetables resides in them. Those seeds which man has appropriated for his food, contain much; and these feculæ form a very nourishing jelly with hot water. It may be seen in the work of M. Parmentier, that this is truly the most suitable nourishment for man. Some of these are even entirely devoted to this purpose, such as the cassava.

In the northern climates, the lichens form almost the whole of the food of man, and such animals as are not carnivorous; and these lichens, according to the experiments of the Academy of Stockholm, afford an excellent starch by simple grinding. The rein-deer, the stags, and the other fallow cattle of the north of Europe, subsist on the lichen *rangiferinus*. The Icelanders obtain a very delicate gruel with the fecula of the lichen *Icelandicus*.

2. Starch boiled in water, and coloured with a small quantity of azure, forms a paste which is used to give brightness, firmness, strength, and an agreeable colour, to linen.

3. The feculæ are also used to make hair powder; and this consumption, which is prodigious, might be supplied by starch made from

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less valuable plants than the gramineous; and, if this were done, the objects of luxury would not enter into competition with our most immediate wants.

A R T I C L E VII.

Concerning the Vegetable Gluten.

The glutinous principle, which, on account of its properties resembling those of animal substances, has been called the *Vegeto-Animal Substance* by some chemists, is more particularly obtained from gramineous vegetables. We are indebted to Beccari for the discovery of this substance; and the analysis of farinaceous substances has since been enriched with various important facts.

To make the analysis of any farina, the methods employed are such as are simple, and incapable of decomposing or altering any of its constituent parts. A paste is formed with the flour and water; and this is kneaded and wrought in the hands under water, till it no longer communicates any colour to that fluid. The substance which then remains in the hand is tenacious, ductile, and very elastic; and becomes more and more adhesive, in proportion as the

water which it had imbibed flies off by evaporation. In this same operation the fecula falls to the bottom of the water; while the extractive matter remains in solution, and may be concentrated by evaporation of the fluid.

If the glutinous matter be stretched out, and then let go, it returns by spontaneous contraction to its original form. If it be left suspended, it becomes extended by its weight; and forms a very thin transparent membrane, which exhibits a kind of net work, resembling the texture of the membranes of animals.

M. Beccari has observed that the proportion of glutinous matter varies prodigiously in the several seeds of gramineous vegetables. Those of wheat contain the largest quantity; but he never found it in the garden stuff or plants which are used by us as food. The quantity of glutinous matter also varies in the same kind of grain, according to the nature of the soil which has supported it. Humid situations afford scarcely any.

The glutinous matter emits a very characteristic animal smell. Its taste is insipid; it swells up upon hot coals; becomes soon and perfectly dry in a dry air, or by a gentle heat; in which state it resembles glue, and breaks short like that substance. If in this state it be placed on
burning

burning coals, it curls up, is agitated, and burns like an animal substance. By distillation it affords the carbonate of ammoniac.

Fresh-made gluten, exposed to the air, readily putrefies; and when it has retained a small quantity of starch, this last passes to the acid fermentation, and retards the putrefaction of the gluten; and in this way a state is produced resembling that of cheese.

Water does not attack the glutinous part. If it be boiled with this fluid, it loses its extensibility and adhesive quality: a circumstance so much the more remarkable, as it was indebted to that fluid for the development of these qualities; for this principle existed without cohesion in the flour; and when it is deprived of water by drying, it also loses its elasticity and glutinous quality.

Alkalis dissolve it, by the assistance of a boiling heat. The solution is turbid; and deposits the gluten by the addition of acids, but deprived of its elasticity.

The nitric acid dissolves gluten with activity: and this acid at first emits the nitrogenous gas, as when treated with animal substances. This is followed by an emission of nitrous gas; and the residue, by evaporation, affords the oxalic acid in crystals.

The

5. The sulphuric and muriatic acids likewise dissolve it. M. Poulletier has observed, that salts with base of ammoniac may be obtained from these combinations, dissolved in water or alcohol, and evaporated in the open air.

6. If the gluten be dissolved in the vegetable acids several times repeatedly, and precipitated by alkalis, it is restored to the state of fecula: and, according to Macquer, if vinegar be distilled by a gentle heat from this substance, it is reduced to the state of mucilage.

7. This substance therefore possesses a very decided animal character. It is to this gluten that wheat owes its property of making a good paste with water, and the facility with which it rises. Rouelle discovered a glutinous substance analogous to the present in the green fecula of plants, which afford ammoniac and empyreumatic oil, by distillation. The expressed juice of the herbaceous plants likewise afforded it, such as that of borage, hemlock, sorrel, &c. &c. The gluten is sometimes destroyed by the fermentation of flour, by which change it is deprived of the wholesome qualities it before possessed, and is incapable of rising, and forming good bread.

Farina, or flour, is therefore composed of three prin-

principles—the amylaceous principle, or starch; the saccharine principle; and the animal or glutinous principle. Whenever therefore, by a suitable division, these principles are mixed together, and the fermentation is assisted by the known methods, each of these principles being capable of a different kind of fermentation, becomes decomposed in its own peculiar manner. The saccharine principle undergoes the spirituous fermentation; the glutinous suffers the process of animal putrefaction; and the amylaceous is changed by the acid fermentation. The panary fermentation may therefore be considered as an union of these three different spontaneous changes. But as soon as the leading phenomena of the fermentation are well developed; and the principles, already well mixed and assimilated, have by this means suffered a change in their respective natures; the fermentation is stopped by baking; and the bread is found to be much lighter in consequence of these preliminary operations.

The art of making bread was not known at Rome until the year 585. The Roman armies, on their return from Macedonia, brought Grecian bakers into Italy. Before this time the Romans prepared their flour in no other way than by making it into pap or soft pudding;
for

for which reason the Romans, according to Pliny, were called Eaters of Pap.* See Aubry;

Article VIII. Concerning Sugar.

Sugar is likewise a constituent part of vegetables, existing in considerable quantities in a number of plants. It is afforded by the maple, the birch, wheat, and Turkey corn. Margraaf obtained it from the roots of beet, red beet, ikirret, parineps, and dried grapes. The process of this chemist consisted in digesting these roots, rasped or finely divided, in alcohol. This fluid dissolves the sugar, and leaves the extractive matter untouched, which falls to the bottom.

In Canada the inhabitants extract sugar from the maple (*acer montanum candidum*). At the commencement of the spring they heap snow in the evening at the foot of the tree, in which they previously make apertures for the passage

* Pulvis autem, non pane, vixisse longo tempore Romanos manifestum, quoniam inde et Pulmentaria hodieque dicuntur. Plin. Hist. Nat. lib. xviii. cap. viii. et xi.—The date is 300 years condit. : T.

of

of the retining sapem: Two hundred pounds of this juice afforded by evaporation fifteen of a brownish sugar. The quantity prepared annually amounts to fifteen thousand weight.

The Indians likewise extract sugar from the pith of the bambou.

But the sugar which is so universally used is afforded by the sugar cane (*arundo saccharifera*) which is raised in our colonies. When this plant is ripe, it is cut down, and crushed by passing it between iron cylinders, placed perpendicularly, and moved by water or animal strength. The juice which flows out by this strong pressure is received in a shallow trough placed beneath the cylinder. This juice is called *vesve*, and the cane, after having undergone this pressure, is called *bagasse*. The juice is more or less saccharine, according to the nature of the soil on which the cane has grown, and the weather that has predominated during its growth. It is aqueous when the soil or the weather has been humid; and in contrary circumstances it is thick and glutinous.

The juice of the cane is conveyed into boilers, where it is boiled with wood ashes and lime.

* These are the names in the French sugar colonies. I do not find the corresponding terms in any of our writers. T.

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It is subjected to the same operation in three several boilers, care being taken to remove the skum as it rises. In this state it is called Syrup, and is again boiled with lime and alum till it is sufficiently concentrated, when it is poured into a vessel called the Cooler. In this vessel it is agitated with wooden stirrers, which break the crust as it forms on the surface. It is afterwards poured into casks, to accelerate its cooling; and, while it is still warm, it is conveyed into barrels standing upright over a cistern, and pierced through their bottom with several holes stopped with cane. The syrup which is not condensed filters through these canes into the cistern beneath; and leaves the sugar in the state called Coarse Sugar, or Muscovado. This sugar is yellow and fat, and is purified in the islands in the following manner:—The syrup is boiled, and poured into conical earthen vessels, having a small perforation at the apex, which is kept closed. Each cone, reversed on its apex, is supported in another earthen vessel. The syrup is stirred together, and then left to crystallize. At the end of fifteen or sixteen hours, the hole in the point of each cone is opened, that the impure syrup may run out. The base of these sugar loaves is then taken out, and white pulverized sugar substituted in its stead;

stead; which being well pressed down, the whole is covered with clay, moistened with water. This water filters through the mass, carrying the Syrup with it which was mixed with the sugar, but which by this management flows into a pot substituted in the place of the first. This second fluid is called Fine Syrup. Care is taken to moisten and keep the clay to a proper degree of softness; as it becomes dry. The sugar loaves are afterwards taken out and dried in a stove for eight or or ten days; after which they are pulverized, packed, and exported to Europe, where they are still farther purified.

The operation of our sugar refiners consists in dissolving the cassonade, or clayed sugar, in lime water. Bullocks blood is added, to promote the clarifying; and, when the liquor begins to boil, the heat is diminished, and the skum carefully taken off. It is in the next place concentrated by a brisk heat; and, as it boils up, a small quantity of butter is thrown in, to moderate its agitation. When the boiling is sufficiently effected, the fire is put out; the liquor is poured into moulds, and agitated, to mix the syrup together with the grain sugar already formed. When the whole is cold, the moulds are opened, the loaves are covered with moistened clay, which is renewed from time to time

time till the sugar is well cleared from its syrup. The loaves being then taken out of the moulds, are carried to a stove, where they are gradually heated to the fiftieth degree of Reaumur. They remain in this stove eight days, after which they are wrapped in blue paper for sale.

The several syrups, treated by the same methods, afford sugars of inferior qualities; and the last portion, which no longer affords any crystals, is sold by the name of Melasses. The Spaniards use this melasses in the preparation of sweetmeats.

A solution of sugar, much less concentrated than that we have just been speaking of, lets fall by repose crystals which affect the form of tetrahedral prisms, terminated by dihedral summits, and known by the name of Sugar Candy.

Sugar is very soluble in water; it swells up in the fire, becomes black, and emits a peculiar smell, known by the denomination of the smell of caramel.

Sugar is very much used for domestic purposes. It constitutes the basis of syrups; and is used at our tables to disguise the sour taste of fruit and vegetable juices. It corrects the bitterness of coffee; and serves as the vehicle in a great number of pharmaceutical preparations.

Sugar is an excellent food; and it is merely an old

old prejudice to suppose it produces worms in the bowels of children.

It is now several years since the celebrated Bergmann taught us to extract a peculiar acid from sugar, by combining the oxigene of the nitric acid with one of its constituent principles. The discovery of the acid of sugar was con- signed in a thesis maintained at Upsal, the 13th of June 1776, by M. Arvidson, under the pre- sidency of Bergmann.

To make the acid of sugar, or oxalic acid, nine parts of the nitric acid, with one of sugar, are put into a retort. A gentle heat is applied, to assist the action of the acid; which is rapidly decomposed upon the sugar, with the disengage- ment of a considerable quantity of nitrous gas. When the decomposition is completed, the dis- tillation is continued on a sand bath, till the residue is sufficiently concentrated. It is then suffered to cool; and beautiful crystals are formed, which may be taken out, and have the figure of a tetrahedral prism terminating in a dihedral summit. By a farther concentration of the liquor in which the acid has crystallized, more of these crystals may be obtained. These several products of crystals are then to be dis- solved in pure water, and again crystallized, to separate them from any admixture of nitric acid

that may adhere to them. This acid was formerly thought to be a modification of the nitric acid; and Bergmann was under the necessity of entering into a considerable detail of reasoning, to remove every doubt on the subject. But the knowledge we at present possess respecting the constituent principles of the nitric acid, and the great number of phenomena of this kind which it exhibits when made to act on various substances, render it unnecessary for us to enter into this consideration.

Cold water dissolves half its weight of this acid, and boiling water takes up its own weight.

This acid, combined with pot-ash, forms a salt in prismatic hexahedral flattened rhomboidal crystals, terminating in dihedral summits. In order that crystallization may take place, it is necessary that one of the component parts should be in excess. This salt is very soluble in water.

The same acid forms with soda a salt which is very difficult to be brought to crystallize, and which converts syrup of violets to a green.

This acid, poured upon ammoniac, affords by a slight evaporation very beautiful tetrahedral prismatic crystals, terminating in dihedral summits; one of whose faces is larger than the other, so that it occupies three angles of the extremity.

extremity. See my Memoirs of Chemistry.— This salt is of great use in the analysis of mineral waters. It instantly shews the presence of any salt with basis of lime, because the oxalate of lime is insoluble in water.

The acid of sugar, or oxalic acid, attacks and dissolves most of the metals: but its action upon the oxides is stronger than upon the metals themselves; and it takes the oxides from their true solvents. In this way it is that it precipitates iron from a solution of the sulphate of iron, in a substance of the most beautiful yellow colour, which may be used in painting.

It precipitates copper in the form of a white powder, which becomes of a beautiful light green by drying.

~~It~~ Zinc is precipitated of a white colour.

This acid likewise precipitates mercury and silver, but not till after several hours standing.

An account of the combinations of this acid with various bases may be seen in Bergmann's treatise.

This acid may be extracted, by the action of nitric acid, from a number of vegetable substances, such as gums, honey, starch, gluten, or alcohol; and from several animal substances, according to the discovery of M. Berthollet, such as silk, wool, and lymph.

M. de Morveau, who has made a very valuable series of experiments on the acid of sugar, has proved that the whole of the sugar does not enter into the formation of the acid, but only one of its principles; and he affirms that it is an attenuated oil which exists in a variety of substances.

Since it has been ascertained, from the experiments of Scheele, Weftrumb, Hermstadt, and others, that the acid of the salt of sorrel does not at all differ from that of sugar, they have been accordingly confounded under the same denomination; and that salt which is known in commerce by the name of Salt of Sorrel, is an acidulous oxalate of potash.

The salt of sorrel is made in Switzerland, in the Hartz, in the forests of Thuringia, in Swabia, and elsewhere. It is extracted from the juice of the sorrel called Alleluya. Juncker, Boerhaave, Margraaff, and others, have described the process used for its extraction. The juice of sorrel is expressed, diluted with water, filtered, and evaporated to the consistence of cream. It is then covered with oil, to prevent its fermentation, and left in a cellar for six months.

According to Mr. Savary, fifty pounds of this plant afford five and twenty of juice, from which no more than two ounces and a half of the

the salt are obtained. Six parts of boiling water dissolve one of the salt. It appears to crystallize in parallelopipedons, according to De Lisle.

Margraff observed that the nitric acid, digested upon salt of sorrel, afforded nitre.

Calcareous earth has the property of disengaging the alkali; and in this operation the carbonic acid of the chalk unites with the alkali of the salt, and forms a carbonate of potash.

Salt of sorrel unites with other bases without yielding its own, so that the results are triple salts. See the *Encyclopedie Methodique*, tom. i. p. 200, 201.

The pure oxalic acid may be obtained by distillation of this salt, as Mr. Savary informs us; or otherwise by depriving it of its alkali by means of sulphuric acid, and distillation, according to Wiegleb's method; or otherwise by the process of Scheele, which consists in saturating the excess of acid with ammoniac, and pouring the nitrate of barytes into the solution. The nitric acid then seizes the two alkalis, while the oxalic acid unites with the barytes, and falls down. The barytes is afterwards taken from its combination by the sulphuric acid, and leaves the oxalic acid disengaged.

Scheele has likewise proposed another method

thod of obtaining the pure oxalic acid. It consists in dissolving the salt in water, and pouring in a solution of salt of saturn. A precipitate is formed; and the supernatant liquor contains the alkali of the salt of sorrel, united with a portion of the vinegar. The precipitate is then washed, and sulphuric acid poured on, which unites with the lead: and, by filtering and evaporating, the oxalic acid is obtained in crystals, similar to those of the acid of sugar.

Scheele has proved the identity of the acid of salt of sorrel with that which is extracted from sugar. He dissolved the acid of sugar to saturation in cold water, and into this he very gradually poured a well-saturated solution of potash. During the effervescence, he observed that small transparent crystals were formed, which were found to be a true salt of sorrel.

Mr. Höffman has proved that the juice and the crystals of the *berberis vulgaris* contain the oxalic acid combined with potash. And the celebrated Scheele has proved that the earth of rhubarb is a combination of the oxalic acid with lime.

ARTICLE IX.

Concerning the Vegetable Acids.

The vegetable acids have been long considered to be weaker than the others; and this opinion was adhered to until it was observed that the oxalic acid seized lime from the sulphuric acid. The principal character which may serve to establish a line of distinction between the vegetable acids and others are—

1. Their volatility; for there are none which do not rise with a moderate heat.
2. Their property of leaving a coaly residue after combustion, and of emitting an empyreumatic smell in burning.
3. The nature of their acidifiable base, which is in general oily.

But are all the vegetable acids identical in their nature? And may they not be considered as modifications of one and the same acid?

If we depend on the principle laid down by the celebrated Monro, who considers no acids as identical but such as form exactly the same salts with the same base (Phil. Trans. vol. lvii. p. 479), there will be no question but that all the known acids ought to be considered as very different from each other. But this method of pro-

proceeding appears to me to be erroneous ; because in this case the various degrees of saturation of the same principle with oxigene, would establish various kinds of acids. The slow or the rapid combustion of phosphorus causes sufficient modifications in the acid to afford different phosphoric salts, according to the Experiments of Mess. Sage and Lavoisier. But ought we on this account to admit of two species of phosphoric acid? By following the method of Monro, which is that of most chemists, we might multiply the vegetable acids to infinity; but by collating the experiments of Hermstadt, Crell, Scheele, Westrumb, Berthollet, Lavoisier, &c. we may observe that the vegetable acids are merely modifications of one or two primitive acids.

1. Scheele obtained vinegar by treating sugar and gum with manganese and the nitric acid. He observed that tartar had the same effect or habitude as sugar in the solution of manganese by the nitric acids; and that vinegar was found after the decomposition of ether.

Mr. Crell, by boiling the residue of nitric alcohol (dulcified spirit of nitre) with much nitric acid, taking care to adapt vessels to condense the vapour, and saturating what came over with alkali, obtained nitrate and the ace-

tate of potash. The latter being separated by alcohol, gives out its vinegar by the usual treatment.

3. The same chemist, by boiling the pure oxalic acid with twelve or fourteen parts of nitric acid, observed that the former disappears; and the receiver is found to contain nitrous acid, acetous acid, carbonic acid, and nitrogenous gas; and in the retort there remains a little calcareous earth*.

4. By saturating the residue of nitric alcohol with chalk, an insoluble salt is obtained; which, treated with the sulphuric acid, affords a true tartareous acid.

5. By boiling one part of oxalic acid with one part and a half of manganese, and a sufficient quantity of nitric acid, the manganese is almost totally dissolved, and vinegar with nitrous acid pass into the receiver.

6. By boiling tartareous acid and manganese with the sulphuric acid, the manganese is dissolved, and vinegar with sulphuric acid are obtained.

7. By digesting for several months the tartareous acid and alcohol, the whole becomes

* There being an obvious oversight in the author's paragraph, I have taken the liberty to restore the passage from Crell's original. *Journal de Phys. Oct. 1785*, quoted by Dr. Beddoes at the end of the English Translation of Scheele's *Essays*. London, 1789. T.

changed into vinegar; and the air of the vessels is found to consist of carbonic acid and nitrogen gas.

From these facts Crell concludes that the tartareous, oxalic, and acetous acids, are merely modifications of the same acid.

In the *Journal de Physique* for September 1787, is inserted a memoir of M. Hermstadt on the conversion of the oxalic and tartareous acids into acetous acid.

1. By causing the oxygenated muriatic acid to pass through very pure alcohol, ether is produced; and the oxygenated acid resumes its character of ordinary muriatic acid. The ether by distillation affords—1. Ether. 2. Muriatic alcohol. 3. Vinegar mixed with regenerated muriatic acid.

2. Nitric acid distilled, for several successive times, from the oxalic and tartareous acids, converts them totally into acetous acid.

3. Two parts of oxalic acid, three of sulphuric acid, and four of manganese, mixed with one part and a half of water, and distilled together, afford acetous acid, which requires to be recohobated and redistilled to become very pure.

4. If the sulphuric acid be boiled upon the oxalic or the tartareous acid, these two last are not destroyed, as Bergmann thought, but they
are

are converted into acetous acid. It is proved, by the experiments of M. Hermstadt, that the sulphureous acid in the receiver, when ether is made, is mixed with much acetous acid.

It appears therefore to be proved that the tartareous, oxalic, and acetous acids differ from each other only in the proportion of oxigene.— In the above experiments the mineral acids are always decomposed; and, by saturating the radical with their oxigene, they constantly form the acetous acid. If the saturation be not exact, the result is either oxalic or tartareous acid; which is still more proved by a fine experiment of M. Hermstadt. If three parts of fuming nitric acid be put into the pneumatic apparatus, and a large jar be adapted, filled with water; if then one part of good alcohol be poured in, by a little at a time, the mixture will be heated every time a drop of the alcohol is let fall, and a great quantity of bubbles will rise into the receiver. When the operation is ended, if care be taken to collect the gas, it will be found to consist of nitrous gas, a small quantity of carbonic acid, and about a twelfth part of the acetous air of Priestley. The residue affords oxalic acid and acetous acid. The oxalic acid disappears if the operation be continued; ether is formed;
and

and the acetous acid remains, and becomes more in quantity.

M. Hermstadt has likewise succeeded in converting the acids of tamarinds, of citrons, of marc of grapes, the juice of plums, apples, pears, gooseberries, berberries, sorrel, and others, into the oxalic, tartareous, and acetous acids.

From all these experiments it appears, that the oxigene, combined with a principle of alcohol, forms the oxalic acid; and that a more accurate saturation of this principle with oxigene forms the tartareous and acetous acids.

M. Lavoisier has proved that the known vegetable acids do not differ from each other but in the proportion of hydrogene and carbone, and in their degree of oxygenation.

I have proved (in the Memoirs of the Academy of Sciences of Paris for the year 1786) that water impregnated with the gas disengaged from the juice of grapes in fermentation, passes to the state of acetous acid.

It appears that the vegetable acids may be considered in two very different points of view. Most of them exist in the plant itself; but the properties and acid characters are disguised by their combination with other principles, such as oils, earths, alkalis, &c. On the other hand, several acids are extracted from vegetables,
which

which did not exist in nature. In this case the plant contained only the radical, and the reagent with which it is treated affords the oxigene.

The mere distillation of most vegetables is sufficient to develop an acid, which was disguised by oily, alkaline, or earthy substances.

1. The peculiar acid called the Pyro-mucilaginous acid, is afforded by distillation by all plants which contain a saccharine juice.

For the preparation of this acid, the quantity of sugar intended to be operated upon is put into a very capacious retort (the large size being requisite, because the matter swells up), and a receiver sufficiently ample to condense the vapour is adapted. An astonishing quantity of carbonic acid and hydrogen gas are disengaged by the first impression of the fire. A brown fluid remains in the receiver, most of which consists of a weak acid, colouring blue paper, and rendered dark by a portion of oil. The retort contains a spongy coal. M. Schrickel advises the rectification of the product of the first distillation from clay, in order to purify the acid: but M. de Morveau has redistilled it without intermedium; and the acid he obtained had only a slight yellow tinge. Its specific gravity was 1,0115, the thermometer standing at twenty degrees.

As

As this acid rises at the same temperature as water, it is not possible to concentrate it by distillation. But this purpose may be effected by freezing; and in this manner it was that M. Schrickel prepared the acid he made use of to ascertain its combinations.

This acid exists in all bodies capable of passing to the spirituous fermentation, while they contain only the radical of the oxalic acid. The pyromucilaginous acid is combined in the vegetable with oils in the saponaceous state.

This concentrated acid has a very penetrating taste. It strongly reddens blue colours. If it be exposed to heat in open vessels, it is dissipated, and leaves only a brown spot. If it be heated in closed vessels, it leaves a more considerable residue, of the nature of the coal of sugar.

This acid speedily attacks the earthy and alkaline carbonates, and forms salts differing from the oxalates. According to M. Schrickel, it dissolves gold. He affirms that he made the experiment in the presence of Fred. Aug. Cartheuser. Lemery had asserted that the spirit of honey possessed this property; and this opinion is likewise supported in the works of Depré, Etmüller, &c. Neumann opposed the assertion; and the experiments of M. de Morveau confirm those of this last chemist.

Silver

Silver is not attacked by the pyromucilaginous acid: but mercury combines with it by virtue of a long digestion. Consult De Morveau.

This acid corrodes lead, and forms a very styptic salt in long crystals. With copper it forms a green solution. It partly dissolves tin, and affords green crystals with iron.

2. The denomination of the Pyroligneous Acid has been given to the acid obtained by distillation from wood. It has been long known that the hardest woods afford an acid principle, mixed with an oil, which partly disguises its properties; but no one had directly attended to a determination of the habitudes of this acid, till M. Goettling published, in Crell's *Annals* for 1779, a series of researches on the acid of wood, and the ether it affords.

M. de Morveau, to obtain this acid, distilled small pieces of very dry beech in an iron retort, by a reverberatory furnace. He changes the receiver when the oil begins to rise, and rectifies his product by a second distillation. Fifty-five ounces of very dry chips afforded seventeen ounces of rectified acid, of an amber colour, not at all empyreumatic; whose specific gravity, compared with that of distilled water, was as 49 : 48.

This acid strongly reddens blue vegetable colours.

colours. One ounce required twenty-three ounces and a half of lime-water for its complete saturation.

It supports the action of heat very well when it is engaged in an alkaline base; but by a strong heat it is burned, like all the vegetable acids.

It does not precipitate martial solutions of a black colour.

It unites with alkalis, earths, and metals. It does not give up lime or barytes to combine with caustic alkalis.

The action of the pyroligneous acid upon metallic substances, and upon alumine, may be compared with that of the acetous acid, and appears to follow the same order.

This acid dissolves near twice its weight of the oxide of lead.

3. The citric acid. Lemon juice is in a disengaged state in the fruit, and exhibits its acid properties without any preparation. This acid is nevertheless always mixed with a mucilaginous principle, capable of altering by fermentation. Mr. Georgius has described, in the Memoirs of Stockholm for the year 1774, a method of purifying this acid without changing its properties. He fills a bottle with lemon juice, closes it with a cork, and preserves it in a cellar.

lar. The acid was preserved for four years, without corrupting. The mucilaginous parts had fallen down in flocks; and a solid crust was formed beneath the cork, the acid itself having become as limpid as water. To dephlegmate the acid, he exposes it to frost; and observes that the temperature ought not to be too cold, because in that case the whole would become solid; and though the acid would thaw the first, it would always be productive of some inconvenience. In order to concentrate it to better advantage, the ice must be separated as it forms. The first ice is tasteless, and the last is rather sour; and by this means the liquor is reduced to half. The acid thus concentrated is eight times as strong, two gros only being required to saturate one gros of potash.

The citric acid, when thus purified and concentrated, may be kept for several years in a bottle; and serves for all uses, not excepting that of making lemonade.

The chemists in general, who have examined the combinations of the citric acid, have used it in its original state, embarrassed with its mucilaginous principle. Such is the result of the experiments of M. Wenzel, who obtained only gummy products. But M. de Morveau having saturated the purified acid with crystals of

potash, found a non-deliquescent salt at the end of a certain time.

The combinations of this acid are little known.

4. The malic acid.—This acid was announced by Scheele in 1785, and published in Crell's Annals. In order to obtain it, the juice of apples is saturated with alkali, and the acetous solution of lead is poured in until it occasions no more precipitate. The precipitate is thenedulcorated, and sulphuric acid poured on it until the liquor has acquired a fresh acid taste, without any mixture of sweetness. The whole is then filtered, to separate the sulphate of lead. This acid is very pure, always in the fluid state, and cannot be rendered concrete.

It unites with the three alkalis, and forms deliquescent neutral salts. When saturated with lime, it affords small irregular crystals, which are soluble only in boiling water. Its habitude with barytes is the same as with lime.

With alumine it forms a neutral salt of sparing solubility in water, and with magnesia a deliquescent salt.

It differs from the citric acid—1. Because the citric acid saturated with lime and precipitated by the sulphuric acid, crystallizes; whereas this is not crystallizable. 2. The malic acid, treated with

with the nitric acid, affords the oxalic acid; the citric acid does not afford it. 3. The citrate of lime is almost insoluble in boiling water: the malate of lime is more soluble. 4. The malic acid precipitates the solutions of the nitrates of lead, of mercury, and of silver; but the citric acid produces no change. 5. If the solutions of the nitrate of ammoniac, and malate of lime, be boiled together for an instant, the latter salt is decomposed, and nitrate of lime falls down; which proves that the affinity of the malic acid with lime is weaker than that of the nitric.

The celebrated Scheele, who has rendered us acquainted with this acid, has published the following table of the fruits which afford this acid, either pure or mixed with other acids.

The expressed juices of the fruits of

Berberria vulgaris, the Barberry tree,	} Afford much malic acid, and little or none of the citric acid.
Sambucus nigra, Elder,	
Prunus spinosa, Sloe,	
Sorbus aucup. Service,	
Prunus domestic. Garden plum,	
Ribes grossularia, the Hairy Gooseberry,	} Appear to contain half of the one and half of the other.
Ribes rubrum, the Currant,	
Vaccinium myrtillus, Whortleberry,	
Crataegus aria, Common Lotus,	
Prunus Cerasus, Cherry,	
Fragaria vesca, Strawberry,	
Rubus chamaemorus, Bilberry,	
Rubus idaeus, Raspberry.	

Vaccinium oxycoccos, Marsh-mallows,
Vaccinium Vitis Idææ,
Prunus padus, Bird's Cherry,
Solanum dulcamara,
Cynobatos, Eglantine,
 Citrus, Citron or Lemon,

} Contain much cit-
 ric, and little
 or none of the
 malic acid.

According to the same chemist, the juice of green grapes, as well as that of tamarinds, contains only the acid of citrons.

Scheele has likewise proved the existence of the malic acid in sugar. If weak nitric acid be poured on sugar, and distilled till the mixture begins to turn brown, all the oxalic acid may be precipitated by the addition of lime-water; and another acid will remain, which the lime-water does not precipitate. To obtain this acid in a state of purity, the liquor is saturated by means of chalk, then filtered, and alcohol added, which occasions a coagulation. This coagulation, well washed in alcohol, is re-dissolved in distilled water. The malate of lime is decomposed by the acetate of lead; and, last of all, the malic acid is disengaged by the sulphuric acid. The alcohol by evaporation leaves a substance rather bitter than sweet, which is deliquescent, and resembles the saponaceous matter of lemon juice. If a small quantity of nitric acid be distilled from this, the malic and oxalic acids are obtained.

By treating various other substances with the
 nitric

nitric acid, the malic and the oxalic acids are likewise obtained. Such are gum arabic, manna, sugar of milk, gum adragant, starch, and the fecula of potatoes. The extract of nut-galls, the oil of parsley-seed, the aqueous extract of aloes, of colocintida, of rhubarb, of opium, afforded not only the two acids to Mr. Scheele, but likewise much resin,

This celebrated chemist, by treating several animal substances with very concentrated nitric acid, obtained the malic and the oxalic acids from them. Fish glue, or isinglas, white of egg, yolk of egg, and blood, treated in the same manner, afforded the same products.

There are few vegetables which do not exhibit some acid more or less developed. We see, for example, all fruits, insipid at first, become insensibly acid; and finish by losing that taste, and become saccharine. There are some which constantly preserve an acid taste, and form a particular class.

Some plants contain an acid principle diffused through the whole parenchyma or body of the vegetable. Such are the yellow gilly-flower, bardana or waterdock, filipendula or dropwort, water cresses, the herb robert, &c. These plants sensibly redden blue paper.

There are others in which the acid principle
exists

exists only in part of the plant ; as, for example, in the leaves of the greater valerian, the fruit of the winter cherry and of the cornel tree, the bark of burdock, and the root of aristolochia or birthwort.

Mr. Monro communicated some experiments to the Royal Society of London, in 1767, which prove that certain vegetables contain acids nearly in a disengaged state, and even such as are the least promising on a slight examination.

1. Having peeled two dozen of summer apples, and cut them into small pieces, he poured water upon them, in which he had previously dissolved two ounces of soda, and left the whole to stand for six days. The filtrated liquor, evaporated, and left in repose for six days more, afforded a beautiful salt, in small round transparent plates, placed edgewise on each other.

2. The juice of mulberries clarified with the white of egg, and saturated with soda, afforded a pulverulent salt of no regular figure ; which by repeated solutions and evaporations, at last produced long crystals, one kind being thin, and the other thicker, which crossed each other.

3. He obtained small cubical or rhomboidal crystals by treating peaches and oranges with soda.

4. The green plum afforded, after several solutions

solutions and crystallizations, a neutral salt, which crystallized without evaporation in large hexagonal plates, and partly in large rhombi. This salt had a hot taste, and was soluble in three or four times its weight of cold water.

5. The red gooseberry afforded, by evaporation and cooling, small very hard rhomboidal crystals, not changeable in the air; whose taste resembled that of the salt produced by a combination of the citric acid with the same base.

The green gooseberry produced a saline crust formed of small rhomboidal crystals, and covered with their brilliant scales.

6. The green grape afforded Mr. Monro, by repeated solutions, a neutral salt, in small cubical crystals, of a rhomboidal or parallelogramic figure, lying upon and intersecting each other.

The juice of hemlock afforded M. Baumé a salt in small irregular crystals, nearly tasteless, but reddening the infusion of turnsole.

7. M. Rinman, in his History of Iron, places the forb-apple and sloe among the substances capable of corroding and cleansing the surface of this metal, on account of their acid.

When, by the decomposition of certain vegetables by the nitric acid, an acid was obtained as the last result, it was thought to have existed ready formed in the vegetable; but a more intimate

timate examination shewed that the acid made use of in this operation was merely decomposed, while it destroyed the organization of the vegetable, disunited the combinations which retained the principles, and that the oxygenous base of this acid, by uniting with an element of the vegetable, formed a peculiar acid. This truth is deduced from the combined processes of M. Lavoisier, De Morveau, &c.

It is to a similar cause that we ought to attribute the formation of the acetous, the carbonic, and other vegetable acids; and even the rancidity of oils, and the alteration to which some other principles of the vegetable kingdom are subject. In these cases the air affords the oxygen which becomes fixed in the plant, and gives it an acid nature.

The oxalic acid does not exist ready formed in sugar, neither is the camphoric acid ready formed in camphor. The same may be observed of several other acids which are extracted by means of certain acids decomposed by being treated with vegetable substances. We shall speak of these acids when we come to treat of their radical principles.

ARTICLE X.

Concerning Alkalis.

Alkali exists ready formed in plants. Duhamel and Groffe have proved that it might be extracted by means of acids. Margraaf and Rouelle have added new proofs in support of the assertions of those chemists. They have observed, from their experiments, that the alkali existed in a disengaged state in vegetables; but these experiments proved at most that their state of combination is such that it may be broken by the mineral acids. The alkali, in some instances, is nearly in a disengaged state; for it is found in combination with carbonic acid in the *helianthus annuus*. But the alkali of plants is often combined with the oily principle.

When it is required to extract the alkali from a vegetable substance, all the principles with which it may be united, are destroyed by fire; and it is cleared from the residues of the combustion by lixiviation. This is the process used to make the impure alkali, called *salin*, as we have already observed.

If wood remains a long time under water, it is deprived of its property of affording an alkali

kali by combustion ; because the water dissolves the compounds which may contain it.

Marine plants afford an alkali of another nature, known by the name of Soda. Vegetables possess the power of decomposing common sea salt, and retaining its alkaline base. All insipid plants are capable of affording more or less of soda, if they be raised on the sea coast ; but they perish there in a short time.

Ammoniac is likewise found in plants. The glutinous part of gramineous vegetables contain it, and give it out to the nitric, muriatic, and other acids, according to M. Poullétier : and nothing more is required than to triturate the essential salt of wormwood with fixed alkali, to separate the volatile. This alkali appears to be one of the principles of the tetradynamia, as these afford it by simple distillation.

Alkalis likewise exist in plants in the state of neutral salts. They are combined with the sulphuric acid in old borage and in some astringent plants. The sulphate of potash appears to exist in almost all vegetables, as the potash contains more or less of it ; and the analysis of tobacco has afforded me a considerable quantity.

Tamarisk affords the sulphate of soda in such abundance, that by extracting it from the ashes
of

of this plant, it can be afforded in very beautiful and pure crystals at thirty livres the quintal.

The greater turnsole, parietaria, and borage contain nitrate of potash.

The muriates of soda and of potash are afforded by marine plants.

We likewise find the alkalis combined with the acids of vegetation, such as the oxalic, the tartareous, and other acids.

It appears that the several salts are the products of the vegetation, and peculiar effect of the organization, of vegetables. Two plants which grow in the same soil, afford very different salts; and each plant constantly affords the same kind. Besides this, Homberg observed (Mem. Acad. Par. 1669) that the same salts were developed by plants growing in earths previously well washed, and afterwards watered with distilled water.

We may therefore class salts among the principles of vegetables, and no longer consider them as accidentally contained in plants. I do not however deny that the combustion of a plant may not give rise to some of them, and increase or diminish the proportions of others. Combustion must form combinations which did not exist in the plant, and destroy several of those which existed before. The atmospheric air employed

employed in this operation must unite with certain principles, and produce various results. The nitrogene gas which is precipitated in torrents in the focus of combustion, probably combines with some of the principles to form alkalis, and consequently may augment the quantity of those which naturally exist in the plant.

A R T I C L E X I .

Concerning the Colouring Principles.

The object of the art of dyeing consists in depriving one body of its colouring principle, to fix it upon another in a durable manner; and the series of manipulations necessary to produce this effect, constitutes the art itself. This art is one of the most useful and wonderful of any we are acquainted with; and if there be any one of the arts which is capable of inspiring a noble pride, it is this. It not only affords the means of imitating nature in the riches and brilliancy of her colours; but it appears to have surpassed her, in giving a greater degree of brilliancy, fixity, and solidity to the fugacious and transient colours with which she has clothed the productions around us.

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The series of operations which constitute the art of dyeing, are absolutely dependent on the principles of chemistry: and though it is to accidents, or the very slight combination of facts suggested by the comparison of a few circumstances, that we are indebted in this part of chemistry for several excellent receipts, and some principles; yet it is not the less true, that no considerable progress will ever be made, nor any solid foundation established, but by analysing the operations, and reducing them to general principles, which chemistry alone can afford. The necessity of establishing proper principles is still farther evinced by the uncertainty and continual trials which prevail in the manufactories. The slightest change in the nature of the substances puts the artist to a stand, in so much that he is incapable of himself of remedying the defects which arise. Whence follow continual losses, and a discouraging alternation of success and disappointment.

The little progress which chemistry has hitherto made in the art of dyeing, depends on several causes, which we shall proceed to explain.

The first cause of this slow progress depends on the difficulty of ascertaining with any degree of certainty the nature, properties, and affinities,
of

of the colouring principle. In order to extract this principle, we must be acquainted with the nature of its solvent ; we must know whether the principle be in a state of purity, or mixed with other parts of the vegetable ; whether this colouring matter consist of one principle alone, or is formed by the union of a number : we must also render ourselves acquainted with its affinities with various kinds of stuff ; for it is ascertained by experience that certain colours adhere very well to wool, though they do not alter the whiteness of cotton. In addition to these necessary parts of knowledge, it will likewise be required to determine its affinity with the mordant, for alum is the mordant for some colours, and not others : besides which, the action or effect of other bodies upon the colour when dyed must be ascertained, in order to contrive the means of defending it from alteration, &c.

The second cause which has retarded the application of chemistry to dyeing, is the difficulty the chemist finds of procuring opportunities of making experiments in the large way. Prejudice, which reigns despotically in the dye-house, tends to expel the chemist as a dangerous innovator ; and the proverb, that *Experience is better than Science*, contributes to prevent the introduction

duction of improvements into manufactories. It is very certain that a dyer, confined to the mere practical part of his business, will without controversy produce a better scarlet than a chemist who is acquainted only with the principles; for the same reason as a simple workman in clock making will make a better watch than the most celebrated mechanic. In these cases we may admit that experience is better than science; but when it is required to resolve any problem, to explain any phenomenon, or to discover some error in the complicated details of an operation, the mere artisan is at the end of his knowledge, is totally at a loss, and would derive the greatest advantage from the assistance of the man of science.

Another cause of the slow progress of chemistry in the art of dyeing, is, that most of the works which treat upon this art are confined to descriptions of the processes used in the manufactories. These works, it must be admitted, possess their advantages; but they do not advance the science of operations a single step. They only exhibit the sketch of a country, without indicating either its relative situation, or the nature of its products. It has indeed been very difficult, till lately, to do more than this; because the gases, which are so greatly concerned

concerned in this part of chemistry were unknown; because the action of light and of the air, which is so powerful upon colours, was a fact of which neither the cause nor the theory could be known; and more particularly because the salts and combinations of three, four and five principles were not known, though they very much tend to render the effects of operations on vegetables more complicated.

In order therefore to make a progress in the art of dyeing, we must ground our reasoning on other principles. I shall proceed to sketch out a plan which seems to me to be adapted to this purpose. We shall examine—

1. The manner in which the colours of various bodies are developed and formed.
2. The nature of the combinations of these same colours in these bodies, and the properest means of extracting them.
3. The most advantageous processes for applying them.

1. Colours are all formed in the solar light. The property which bodies possess of absorbing some rays, and reflecting others, forms the various tinges of colours with which they are decorated, as is proved from the experiments of Newton.

From this principle we may consider the art of dyeing under two very different points of view.

For

For we may determine the colour upon a body either by changing the form and disposition of its pores ; so that it may acquire the property of reflecting a different kind of rays from those which it reflected before it was subjected to these mechanical operations. Thus it is that by trituration we change the colour of many bodies ; and to this cause it is that we must refer all the effects dependant on the reflexivity and refrangibility of rays. This coloration depends, as we see, merely on the changes produced in the surfaces of bodies, or the disposition of their pores. The phenomena of refrangibility depend on the density or specific gravity of bodies, according to Newton and Delaval.

The other method of causing a body to exhibit a determinate colour, consists in transferring to the surface of the body some other body or substance which possesses the property of reflecting this known ray. This is the effect chiefly produced by dyeing.

But in what manner do the coloured bodies of the three kingdoms of nature acquire the property of constantly reflecting one determinate kind of rays ? This is a very delicate question ; for the elucidation of which I shall bring together a few facts.

It appears that the three colours which are the most eminently primitive in the arts; those which form all the others by their combination, and consequently the only colours to which we need pay attention; that is to say, the blue, the yellow, and the red—are developed in the bodies of the three kingdoms by a greater or less absorption of oxigene, which combines with the various principles of those bodies.

In the mineral kingdom, the first impression of fire, or the first degree of calcination, develops a blue colour, sometimes interspersed with yellow, as is observable when lead, tin, copper, iron, or other metals, are exposed in a state of fusion to the action of the air, to hasten their cooling. This may be especially observed in steel plates which are coloured blue by heating.

Metals acquire the property of reflecting the yellow colour by combining with a greater quantity of oxigene; and accordingly we perceive this colour in most of them, in proportion as the calcination advances. Massicot, litharge, ochre, orpiment, and yellow precipitate, are instances of this.

A stronger combination of oxigene appears to produce the red; whence we obtain minium, colcothar, red precipitate, &c.

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This process is not uniform through all the
ies of the mineral kingdom; for it is natu-
to infer that the effects must be modified
re nature of the base with which the oxi-
combines. Thus it is that in some of
them we perceive the blue colour almost im-
mediately followed by a black; as may easily
be accounted for, on the consideration that
there is a very slight difference between the
property of reflecting the weakest rays and
that of reflecting none at all.

To give additional force to the observations
here made, we may also take notice that the
metals themselves are most of them colourless,
and become coloured by calcination; that is
to say, by the fixation and combination of oxi-
gene.

The effects of the combination of oxigene
are equally evident in the mineral as in the ve-
getable kingdom; and, in order to convince
ourselves of this, we need only follow the ope-
rations in the method of preparing and deve-
loping the principal blue colours, such as in-
digo, pastel, turnsole, &c.

Indigo is extracted from a plant known by
the name of Anillo by the Spaniards, and the
Indigo Plant by us. It is the *Indigofera tinctoria*
of Linnaeus. It is cultivated at Saint Do-

mingo, in the Antilles, and in the East Indies. The boughs are cut every two months, and the root lasts two years. The plant is laid to ferment in a trough called the steeping trough, which is filled with water. At the end of a certain time the water heats, emits bubbles, and becomes of a blue colour. It is then passed into another vessel or trough, called the beating trough (*batterie*), where the fluid is strongly beaten or agitated by a mill with pallets, to condense the substance of the indigo. As soon as the water is become insipid, it is drawn off; and the deposition of the fecula is made in a third vessel, called the settling trough (*repositoir*), where it dries, and is taken out to form the loaves distributed in commerce.

The pastel is a colour which is extracted in Upper Languedoc, by fermenting the leaves of the plants after having first bruised them. The fermentation is promoted by moistening them with the most putrid water that can be procured.

The woad is prepared in Normandy in the same manner as the pastel.

Turnsole is prepared at Grand Galargues by soaking rags in the juice of the croton tinctorium, and afterwards exposing them to the vapour of urine or dung.

We likewise observe that the first degree of
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combination of oxigene with oil (in combustion) develops the blue colour for the instant.

The blue colour is formed in dead vegetables only by fermentation. Now in these cases there is a fixation of oxigene. This oxigene combines with the fecula in indigo, with an extractive principle in turnsole, &c. ; and most colours are likewise susceptible of being converted into red by a greater quantity of oxigene. Thus it is that turnsole reddens by exposure to air, or to the action of acids : because the acid is decomposed upon the mucilage, which is the receptacle of the colour ; as may be seen in syrup of violets, upon which the acids are decomposed when concentrated. The same thing does not happen when a fecula is saturated with oxigene, and does not admit of the decomposition of the acid. Hence it is that indigo does not become red by acids, but is, on the contrary, soluble in them. It is likewise for the same reason that we observe a red colour developed in vegetables in which an acid continually acts, as in the leaves of the oxalis, of the virgin vine, the common sorrel, and the ordinary vine. Hence also it happens that acids brighten most of the red colours ; and that a very highly charged metallic oxide is used as the mordant for scarlet.

We find the same colours developed in the animal kingdom by the combination of the same principle. When flesh meat putrefies, the first impression of the oxigene consists in producing a blue colour; whence the blue appearance of mortifications, of flesh becoming putrid, of game too long kept, or the appearance which in our kitchens in France is called *cordon bleu*. This blue colour is succeeded by red, as is observed in the preparation of cheeses, which become covered with a mouldiness at first of a blue colour, but afterwards becoming red: I have pursued these phenomena in the preparation of cheeses at Roquefort. The combination of oxigene, and the proportional quantity which enters into such combination, determine therefore the property of reflecting any particular rays of light. But it may easily be understood that the colour must be subject to variation, according to the nature of the principle with which it combines; and this points out a series of very interesting experiments that remain to be made.

All the phenomena of the combination of air, with the several principles in different proportions, may be observed in the flame of bodies actually on fire. This flame is blue when the combustion is slow; red, when
stronger

stronger and more complete; and white, when still more perfect. For these final degrees of oxidation in general produce a white colour, because all the rays are then equally reflected.

From the foregoing facts we may conclude that the blue ray is the weakest, and is consequently reflected by the first combination of oxigene. We may add the following fact to those we have already exhibited. The colour of the atmosphere is blueish: the light of the stars is blue, as M. Mariotte has proved, in the year 1678, by receiving the light of the moon upon white paper: the light of a clear day reflected into the shade by snow, is of a fine blue, according to the observations of Daniel Major (*Ephem. des Curios. de la Nature*, 1671, premier Dec.).

The colouring principle is found in vegetables in four states of combination—1. With the extractive principle. 2. With the resinous principle. 3. With a fecula. 4. With a gummy principle.—These four states in which we find the colouring principle, indicate to us the means of extracting it.

A. When the receptacle of the colour is of the nature of extracts, water is capable of dissolving the whole: such is that of logwood, turnsole, madder, cochennille, &c. Nothing
more

more is necessary than to infuse these substances in water, for the purpose of extracting their colouring principle. If any stuff be plunged in this solution, it will be covered with a body of colour, which will be a mere stain, that may be again cleared off by water. To obviate this inconvenience, it has therefore been found necessary to impregnate the stuffs on which the colours were intended to be applied with some salt or other principle, which might change the nature of the colouring matter, and give it fixity, by depriving it of its solubility in water. It is this substance which is distinguished by the name of Mordant. It is likewise necessary that the mordant should have an affinity with the principle of colour, in order that it may become its receiver. Hence it arises that most of these colours, such as turnsole, Brasil wood, &c. are not fixed by these mordants; hence also it arises that cochénille does not form a fine scarlet, unless it has tin for its mordant. It is necessary, moreover, that the mordant have a due relation to the nature of the stuff; for the same composition which gives a fine scarlet colour to wool, gives a colour of wine lees to silk, and does not even change the white colour of cotton.

B. There are certain resinous colouring matters

ters soluble in spirit of wine: such are the pharmaceutical tinctures: they are used only in the arts for dyeing ribbons. There are other colouring matters combined with feculæ, which water does not dissolve: rocou, archil, indigo, and the red colour of oriental saffron, are of this kind.

Rocou is a resinous fecula obtained by macerating the seeds of an American tree called Urucu in water. In this operation the extractive part is destroyed by fermentation, and the resinous fecula is collected in a paste of a deep yellow colour. The paste of rocou, diffused in water with the impure alkali called *cendres gravelées*, affords a fine orange colour.

Archil is a paste prepared by macerating certain mosses and lichens in urine with lime. Alkalis extract a violet colour. Archil is made in Corsica, in Auvergne, at Lyons, &c.

The archil of the Canaries is less charged with lime. That which I procured, exhibited in its texture the fibres of the plant, not completely decomposed by the fermentation. The archil of the Canaries, or the archil in the herb, is afforded by the lichen called, *Orcella, rocella, lichen fruticulosus, solidus, apbyllus, subramosus, tuberculis alternis, Linnæi*. The parella or archil
of

of Auvergne is made with the *lichen parellus* Linnæi.

The colouring matters of this class are all soluble in alkali or lime; and these are the substances used to dissolve them in water, and precipitate them upon stuffs. Lime is the true solvent of indigo; but alkali is the solvent of other substances of the same class. For example: when it is required to make use of the colouring matter of bastard saffron, the first proceeding consists in washing it in much water, to clear it of the extractive and yellowish principle, which is very abundant; and the resinous principle is afterwards dissolved by means of alkali, from which solvent it is precipitated upon the stuffs by means of acids. In this manner it is that the poppy-coloured silk is made. This resinous principle may also be combined with talc, after it has been extracted by an alkali, and precipitated by an acid; in which case the result is vegetable red. To make this pigment, the yellow colour of saffron or carthamus is first extracted by means of washing. Five or six per cent. of its weight of soda is mixed with the residue; and cold water is poured on, which takes up a yellow matter; and this, by the addition of lemon juice, deposits a red fecula. The red fecula, mixed with levigated talc,

talc, and moistened with lemon juice, forms a paste, which is put into pots to dry. If the red be soluble in spirit of wine, it is vegetable; but if not it is mineral, and is usually vermilion.

Acids may be used instead of alkalis in fixing some of these colours upon stuffs. To make a permanent blue, instead of dissolving indigo by means of lime, it is sometimes dissolved in oil of vitriol. This solution is poured into the bath, and the alumed stuff is passed through it. Flannels are dyed blue at Montpellier in this way. This operation depends merely on an extreme division of the indigo by the acid.

D. There are some colouring principles fixed by a resin; but which, by the assistance of extractive matter, may be suspended by water. The stuffs are boiled in this solution; the resinous part applies itself to them, and adheres with sufficient solidity not to be again carried off by water.

No preparation is required to dye with these ingredients, nothing more being necessary than to boil the stuff in a decoction of the colour. The principal substances of this kind are, the husk of walnuts, the roots of the walnut-tree, sumach, fantal, the bark of elder, &c. All these substances, which require no mordants, afford

afford only a buff-coloured tinge, which dyers call Root Colours. The colouring matter of certain vegetables may likewise be extracted by oils. In this way oils are coloured red by infusing alkanet, or the root of a certain species of bugloss in them.

In order to apply colouring matter properly upon any stuff, it is necessary to prepare the stuff, and dispose it to receive the colouring principle. For this purpose it must be washed, bleached, and cleared of that glutinous matter which defends it from the destructive action of the air while it grows on the animal which affords it; and impregnated with the mordant which fixes the colour, and gives it peculiar properties.

-A. The first operation required to dispose a stuff to receive colour, is bleaching; because the whiter it is, the more natural and accurate will be the colour it takes. If this precaution be not taken, the success will be uncertain. To bleach piece-goods, the operator is satisfied with boiling them in an alkaline lixivium, and exposing them afterwards to the air, to render the whiteness more perfect. This operation depends on the action of the oxigene, which combines with the colouring principle, and destroys it; as is evidently demonstrated by the late experiments of M. Berthollet on the oxigene

generated muriatic acid, which bleaches cloths and cottons with such facility, that it is already used for this purpose in several manufactories.

Cotton is bleached in some manufactories by a very ingenious process. A boiler is firmly set in masonry, and a cover fitted to it in the strongest manner; this boiler has an elliptical figure. Alkali rendered caustic by lime is put into the bottom of this vessel; and the goods intended to be bleached are put into a basket, which prevents their touching the sides of the boiler. When the piece-goods are properly placed, the covering is fixed on, which is pierced by a very small aperture, to permit a portion of the aqueous vapour to escape. A degree of heat much superior to that of boiling water is excited in the solution of potash; and the heat, assisted by the corrosive action of the potash in this kind of Papin's digester, destroys the colouring principle of the cottons, and gives them the utmost whiteness.

B. That kind of gluten which envelops almost every animal substance, but more especially raw silk, is insoluble in water and in alcohol. It is only attacked by alkalis and soaps; and for this purpose the operation of cleansing is used. Any stuff may be cleared of its glutinous part by boiling or even digesting it in a solution

solution of alkali : but it has been observed that a pure alkali alters the goodness and quality of the stuff; for which reason soaps have been substituted in its stead. For this purpose the stuff is steeped in a solution of soap, heated to a less degree than boiling. The academy of Lyons, in the year 1761, proposed a prize for the means of clearing raw silks without soap. It was adjudged to M. Rigaut, of St. Quentin, who proposed a solution of salt of soda.

It has been lately ascertained that water, heated above the degree of ebullition, is capable of dissolving this colouring principle. A boiler similar to that which I have just described, may be used for this purpose.

In order to bleach cotton, and dispose it for the dyeing processes, it is cleansed by means of a liquid soap made of oil and soda.

The piece-goods are cleared by this boiling from the varnish, which would prevent the colour from applying and fixing itself in a permanent manner; at the same time that it opens the pores of the stuff for the better reception of the colour.

When the piece is thus prepared, its pores being very open, and its colour very white, nothing remains to be done previous to the application of the dye, but to impregnate it with the mordant or principle which is to receive

ceive the colour; and change its nature so much, that neither water, soap, nor any of the reagents used as proofs, may be capable of extracting it. It is necessary therefore—1. That the mordant itself should be very white, that it may not alter the colour presented to it. 2. That it be not subject to corruption; and for this purpose it must be sought among the earths and metallic oxides. 3. That it be in a state of extreme division, in order that it may fix itself in the pores. 4. That it be insoluble in water and the other reagents. 5. That its affinity with the colouring matter and the stuff be very great.

Alum, and the muriate of tin, are the two salts whose bases unite these properties in the most efficacious manner. The stuffs having undergone the previous operations, are therefore steeped in solutions of these salts; and when they are impregnated, they are passed through the colouring bath: and by the decomposition, or change of principles between the mordant and the principle which holds the colour in solution, the colour is precipitated on the base of the mordant, and adheres to it.

Certain vegetable substances are likewise disposed to take some colours by animalizing them. In this way cows dung and bullocks blood

blood are used in dyeing cotton; for it is a decided fact that animal substances take colours better than vegetables.

ARTICLE XII.

Concerning the Pollen, or Fecundating Powder of the Stamina of Vegetables.

Modern discoveries and observations have pointed out the sexual parts of plants; and we find nearly the same forms in the organs, the same means in the functions, and the same characters in the prolific humours, as in animals.

The prolific humour in the male part is elaborated by the anthera; and as the organs of the plant do not admit of an actual intromission of the male into the female, because vegetables are not capable of loco-motion, nature has bestowed on the fecundating seed the character of a powder; which the agitation of the air, and other causes, may carry away and precipitate upon the female. There is a degree of elasticity in the anthera, which causes it to open, and eject the globules. It has even been observed that the pistil opened at the same time, to receive the pollen, in certain vegetables. The resources
of

of nature to assure the fecundation are admirable. The male and female parts almost always repose in the same flower; and the petals are always disposed in the most advantageous manner to favour the reproduction of the species. Sometimes the male and female are upon the same individual, but placed upon different flowers; at other times both are attached to isolated and separate individuals, and then the fecundation is made by the pollen which the wind or air detaches from the antheræ, and transmits to the female.

The fecundating powder has almost constantly the smell of the spermatic liquor of animals. The smell of cabbages in blossom, of the chestnut tree, and most other vegetables, exhibits this analogy to such a degree, that the one odour might even be mistaken for the other.

The pollen is generally of a resinous nature, soluble in alkalis and in alcohol. Like resins, it is inflammable; and the *aura* which is formed around certain vegetables at the time of fecundation, may be set on fire, as was observed by Mademoiselle Linné in the *fraxinella*.

Nature, which has employed less œconomical means in the fecundation of plants, and who entrusts these operations almost to chance, since she delivers the fecundating powder to the

winds, must of course have been prodigal in the formation of this humour, more especially for the trees of the monoecia and dioecia genera, where the production is more exposed to accidental impediments. Hence we may account for those pretended showers of sulphur, which are never common but in such districts as abound with the hazel, filbert, and pine-trees.

As the pollen could not be exposed by nature to the varying temperatures of the atmosphere, she has facilitated its development in the most rapid manner. A warm sun very frequently suffices to open the concealed organs of the plant, to develop and procure its fecundation. On this account the author of *Les Etudes de la Nature* affirms, that the coloration of plants is designed to reflect the light more vividly, and most flowers affect the most advantageous form to concentrate the solar rays on the parts of generation.

The parts employed in these functions are endowed with an astonishing degree of irritability. M. des Fontaines has made some very interesting observations on this subject; and the agitated motions which some plants affect in order to follow the course of the sun, are determined by nature, in order that the great work of generation, favoured by the sun, may be accomplished in the least possible time.

Con-

Concerning Wax.

The wax of bees is merely the pollen very little altered. These insects have their *femurs* provided with rugosities to brush the pollen from the antheræ, and convey it to their nests.

There appears to exist in the very texture of some flowers, which are rich in fecundating powder, a matter analogous to wax, which may be extracted by aqueous decoction. Such are the male catkins of the *betula alnus*, those of the pine, &c. the leaves of rosemary, of official sage; the fruits of the *mirica cerifera*, suffer wax to transude through the pores.

It appears that wax and the pollen have for their basis a fat oil, which passes to the state of resin by its combination with oxygen. If the nitric or muriatic acid be digested upon fixed oil for several months, it passes to a state resembling wax.

Wax, by repeated distillations, affords an oil which possesses all the properties of volatile oils. It is reduced into water and carbonic acid by combustion.

The colouring matter of wax appears to be of the same nature as that of silk; it is insoluble

in water and in alcohol. In the arts, wax is bleached by dividing it prodigiously; for which purpose it is poured in fusion upon the surface of a cylinder, which revolves at the surface of water. The wax which falls applies itself to the superficies, and is reduced into very thin flakes or ribbons. It is afterwards exposed to the air upon tables, taking care to stir it from time to time, and by this means it becomes white.

Alkalis dissolve wax, and render it soluble in water. It is this saponaceous solution which forms the punic wax. It may be used as the basis of several colours; and may be made into an excellent paste for washing the hands. It is likewise applied with a brush upon several bodies: but it would be highly advantageous if it could be deprived of its solvent, which constantly acts, and is the cause why it cannot be applied to several uses, in which otherwise it might be found advantageous.

Ammoniac likewise dissolves it; and as this solvent is evaporable, it ought to be preferred when it is proposed to use the wax as a varnish.

ARTICLE XIX.

Concerning Honey.

Honey, or the nectar of flowers, is contained chiefly in the base of the pistil, or female organ. It serves as food for most insects which have a proboscis. These animals plunge their proboscis into the pistil, and suck out the nectar. It appears to be a solution of sugar in mucilage: the sugar is sometimes precipitated in crystals, as in the nectar of the flower of balsamina.

The nectar undergoes no alteration in the body of the bee, since we can form honey by concentrating the nectar. It retains the odour, and not unfrequently the noxious qualities of the plant which affords it.

The secretion of the nectar is made during the season of fecundation. It may be considered as the vehicle and recipient of the fecundating dust, which facilitates the bursting of the globules, filled with this fecundating powder: for Linnæus and Tournefort have both observed that nothing more is required than to expose the pollen upon water, to assist the development. All the internal part of the style of the pistil is impregnated with it. And if the
inter-

internal part of the female organs be dried by heat, the pollen no longer fecundates.

Honey exudes from all the female parts, but particularly from the ovaria. Pores may even be observed in hyacinths, through which it flows.

Such flowers as have only the male parts do not in general afford honey; and the organs which afford the nectar dry up and wither from the moment the act of conception is accomplished. Honey may therefore be considered as necessary to fecundation; it is the humour afforded by the female to receive the fecundating powder, and facilitate the opening and explosion of the small bodies which contain the pollen; for it has been observed that these bodies open the moment they touch the surface of any liquid which moistens them.

A R T I C L E X I V .

Concerning the Ligneous Part of Vegetables,

Chemists have constantly directed their attention to the analysis of vegetable juices: but they appear to have completely neglected the solid part of the vegetable, which in every point of view is entitled to particular attention. It is
this

this ligneous portion which forms the vegetable fibre; and this matter not only constitutes the basis of the vegetable, but is likewise developed in circumstances which depend on the vital functions of the plant. It forms the pulp of seeds, the lanuginous covering which over-spreads certain plants, &c. The character of the ligneous part is, an insolubility in water and almost every other menstruum. The sulphuric acid only blackens it, and is decomposed upon it, as is likewise the nitric acid. But one very peculiar character of this principle is, that the concurrence of air and water alters it very difficultly; and that, when it is well deprived of all its moisture, it absolutely resists every kind of fermentation; insomuch that it would be indestructible, if insects had not the property of gnawing and feeding upon it. It appears that the vegetable fibre consists of the basis of mucilage, hardened by its combination with a greater quantity of oxigene. Several reasons lead us to adopt this idea. In the first place, the diluted nitric acid being put to digest upon fecula, is decomposed, and causes the fecula to pass to a state resembling that of ligneous matter. I have observed, in the second place, that those fungi which grow in subterraneous places void of light, and are resolved into
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a very acid water, if left in a vessel, acquire a greater quantity of the ligneous principle, in proportion as they are exposed by degrees to the light; at the same time that the acid is diminished by decomposition, and at length disappears.

The transition of mucilage to the state of ligneous matter is very evident in the growth of vegetables. The cellular envelop which is immediately covered by the epidermis exhibits nothing but mucilage and glands; but by degrees it hardens, forms a stratum of the cortical coating, and at last concludes by becoming one of the ligneous rings.

We observe this transition in certain plants which are annual in cold climates, and vivacious in temperate climates. In the former they are herbaceous, because the periodical return of the cold weather does not permit them to develop themselves. In the second they become arboreſcent; and the progress of time hardens the mucilage, and forms ligneous coatings.

The induration of the fibrous part may be accelerated by causing the air and light to act more strongly upon it. M. de Buffon has observed that, when a tree is deprived of its bark, the external part of the wood which is exposed to the air acquires a considerable degree of

hardness; and trees thus prepared form pieces of carpentry much more solid than those which have not undergone such preparation.

It is probably owing to the large quantity of pure air with which the fibrous matter is loaded, that it is not disposed to putrefy: and it is in consequence of this most valuable property of not being subject to corruption, that arts have been invented for clearing it of all fermentable principles of the vegetable kingdom, to obtain it in its greatest purity in the fabrication of cloths, paper, &c. We shall again return to these objects, when we treat of the alterations to which the vegetable kingdom is subject.

ARTICLE XV.

Concerning other fixed Principles of the Vegetable Kingdom.

The volatile oil of horse-radish had formerly afforded sulphur, which is deposited by standing, according to the observation of some chemists; but M. Deyeux has taught us to extract this inflammable principle from the root of the herb patience. Nothing is required to be done but to rasp the root, boil it, take off the scum, and

and dry it. This scum affords much sulphur in substance; and it is perhaps to this principle that these plants owe their virtue, since they are used in skin disorders.

Vegetables in their analysis likewise present us with certain metals, such as iron, gold, and manganese. The iron forms near one-twelfth of the weight of the ashes of hard wood, such as oak. It may be extracted by the magnet. It does not appear to exist in a perfectly disengaged state in the vegetable; nevertheless we read, in the *Journaux de Physique*, an observation in which it is affirmed, that it was found in metallic grains in fruits. The iron is usually held in solution in the acids of vegetation, from which it may be precipitated by alkalis. The existence of this metal has been attributed to the wearing of ploughshares, and other instruments of husbandry, and to the faculty which plants possess of imbibing it with their nutritive juices. The Abbé Nolet and others have embraced this unphilosophical notion. It is the same with the iron as with the other salts. They are produced by vegetation; and vegetables watered with distilled water afford it as well as others.

Beecher and Kunckel ascertained the presence of gold in plants. M. Sage was invited to repeat the processes by way of ascertaining the

the fact. He found gold in the ashes of vine twigs, and announced it to the public. After this chemist, most persons who have attended to this object have found gold; but in much less quantity than M. Sage had announced. The most accurate analyses have shewn no more than two grains; whereas M. Sage had spoken of several ounces in the quintal. The process for extracting gold from the ashes consists in fusing them with black flux and minium. The lead which is produced is then cupelled, to ascertain the small quantity of gold with which it became alloyed in this operation.

Scheele has also obtained manganese in the analysis of vegetable ashes. His process consists in fusing part of the ashes with three parts of fixed alkali, and one-eighth of nitrate of potash. The fused matter is boiled in a certain quantity of water. The solution being then filtered, is saturated with sulphuric acid, and at the end of a certain time manganese falls down.

Lime constantly enough forms seven-tenths of the fixed residue of vegetable incineration. This earth is usually combined with the carbonic acid. Scheele has proved that it effloresces in this form on the bark of guaiacum, the ash, &c. It is likewise very often united with the acid of vegetation. It appears to be formed

ed by an alteration of the mucilage, more advanced than that which forms the fecula, which has some analogy with this earth. We evidently see the transition of mucilage to the state of earth in testaceous animals. We observe the mucilage putrefy at its surface, with so much the more facility as it is purer; as we may judge by a comparison of the asteriæ, the sea hedge-hog, the crab, &c.

Next to lime, alumine is the most abundant earth in vegetables, and next magnesia. M. Darcet has obtained, from one pound of the ashes of beech, one ounce of the sulphate of magnesia, by treating them with the sulphuric acid. This earth is very abundant in the ashes of tamarisc. Siliceous earth likewise exists, but less abundantly. The least common of all is the barytes.

ARTICLE XVI.

Of the common Juices extracted by Incision
or Expression.

The vegetable juices hitherto treated of are peculiar substances contained in vegetables, and possessing striking characters, by which they are distinguishable from every other humour.

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But we may at once extract from vegetables all the juices they contain ; and this mixture of various principles may be obtained by several methods. Simple incision is sometimes sufficient ; but expression is equally used.

The juices of vegetables vary according to the respective nature of the plants. They are more abundant in some than in others. Age modifies them. Young trees in general have most sap ; and this sap is milder, more mucilaginous, and less charged with oil and resin. The sap varies according to the season. In the spring the plants draw up with avidity the juices afforded by the air and the earth ; these juices establish a plethora every where, from which results a considerable growth of the individual, and sometimes a natural extravasation. If in the time of plethora incisions be made in any part of the vegetable, all the abundant sap escapes by the aperture ; and this fluid is almost always clear, and without smell. But by degrees the plant elaborates these juices, and gives them peculiar characters. In the spring the sap in the body of the vegetable presents only a slight alteration of the nutritive juices ; but in the summer the whole is elaborated, all is digested, and then the sap possesses characters very different from those it possessed during the spring season.

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If incisions be now made in the tree, the juices obtained are accordingly very different : and for this reason it is that the juices dispersed in commerce are extracted during the summer.

The constitution of the air equally influences the nature of vegetable juices. A rainy season opposes the development of the saccharine principle, as well as the formation of resins and aromatic substances. A dry season affords little mucilage, but much resin and aromatic principle ; hot weather decomposes the mucilage, and favours the development of resins, saccharine matter, and aroma ; but a cold season does not permit the formation of any principle but mucilage : and as the mucilage is the principle of increase of bulk in plants, the whole of this substance is employed for that purpose ; while the heat and light modify the same mucilage, and cause it to pass to the state of oil, resin, aroma, &c. Hence probably it is that trees have a more agreeable appearance in cold than in burning climates ; and that the trees in this latter situation abound with aromatic, oily, and resinous principles. In the vegetable as in the animal kingdom, spirit appears to be the portion of the southern climates ; while force and strength are attributes of the northern.

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Concerning the Juices extracted by Incision.

The juice contained in plants, and known by the name of Sap, is dispersed through the cellular tissue, inclosed in the vessels, or deposited in the utricles; and there is a communication existing, which, when any part of the vegetable is wounded, causes the abundant juices to flow through the aperture; not indeed so speedily nor so completely as in animals; because the humours do not possess so rapid a motion, and because there is less connection between the several organs in vegetables than in animals. The sap is a confused mixture of all the principles of vegetables. The oil and the mucilage are confounded with the salts. It is, in a word, the general humour of vegetables, in the same manner as the blood in animals. In the present place we shall speak only of manna and opium.

1. **Manna.**—Several vegetables afford manna; it is extracted from the pine, the fir, the maple, the oak, the juniper, the fig, the willow, the olive, &c. but the ash, larch, and the alhagi, afford it in the largest quantities. L'Obel, Rondelet, and others, have observed at Montpellier, upon the olive trees, a kind of manna, to which they have given the name of œliomeli.

meli. Tournefort collected it from the same trees at Aix, and at Toulon.

The ash which affords manna grows naturally in all temperate climates; but Calabria and Sicily appear to be the most natural countries to this tree; or at least it is only in these countries that it abundantly furnishes the juice called Manna in commerce.

The manna flows naturally from this tree, and attaches itself to its sides in the form of white transparent drops; but the extraction of this juice is facilitated by incisions made in the tree during summer: the manna flows through these apertures upon the trunk of the tree, from which it is detached with wooden instruments. Care is likewise taken to insert straws, or small sticks of wood, into these incisions; and the stalactites which hang from these small bodies are separated, and known in commerce by the name of Manna in Tears: the smallest pieces form the manna in sorts or flakes; and the common or fat manna is of the worst quality, because the most contaminated with earth and other foreign substances. The ash sometimes affords manna in our climates, specimens of which I have seen collected in the vicinity of Aniane.

The larch, which grows abundantly in Dauphiny, and the environs of Briançon, likewise affords

affords manna. It is formed during the summer on the fibres of the leaves, in white friable grains, which the peasants collect and put into pots, which they keep in a cool place. This manna is of a yellow colour, and has a very nauseous smell.

The alhagi is a kind of broom, which grows in Persia. A juice transudes from its leaves, in the form of drops of various sizes, which the heat of the sun indurates. An interesting account of this tree may be seen in Tournefort's Travels. This manna is known in the Levant, in the town of Tauris, by the name of Terebinthin.

The manna most frequently used is that of Calabria. Its smell is strong, and its taste sweetish and nauseous: if exposed on hot coals, it swells up, takes fire, and leaves a light bulky coal.

Water totally dissolves it, whether hot or cold. If it be boiled with lime, clarified with white of egg, and concentrated by evaporation, it affords crystals of sugar.

Manna affords by distillation water, acid, oil, and ammoniac; and its coal affords alkali.

This substance forms the basis of most purgative medicines.

a. Opium.—The plant which affords opium is the poppy, which is cultivated in Persia and

Asia Minor. To extract this precious medicine, care is taken to cut off all the flowers which would load the plant, and to leave that only which corresponds with the principal stem. At the beginning of summer, when the poppy-heads are ripe, incisions are made quite round them, from which tears flow that are carefully collected. This opium is the purest, and is retained in the country for various uses. That which comes to us is extracted by pressure from the same heads. The juice thus obtained is wrapped up, after previous drying, in the leaves of the poppy, and comes to us in the form of circular flattened cakes.

In our laboratories it is cleared from its impurities by solution in hot water, filtration, and evaporation to the consistence of an extract. This is the extract of opium.

Opium contains a strong and narcotic aroma, from which it is impossible to clear it, according to Mr. Lorry. It likewise contains an extract soluble in water, and a resin; together with a volatile concrete oil, and a peculiar salt.

By long digestion in hot water the volatile oil becomes attenuated, is disengaged, and carries the aroma with it; so that by this means the oil and aroma may be separated, at least for the most part. It has been observed that opium de-

deprived of this oil, a portion of its aroma, and its resin, preserved its sedative virtue, without being narcotic and stupifying. We are indebted to Baumé for a series of interesting researches on this subject. He boiled four pounds of sliced opium in between twelve and fifteen pints of water, for half an hour. The decoction was strained with pressure; the dregs were exhausted by ebullition with more water. All these waters were mixed together, and reduced by evaporation to six pints. The liquor was then put into a cucurbit of tin, and digested on a sand-bath for six months, or during three months night and day. Care was taken to add water as the evaporation proceeded; and the bottom of the vessel was scraped from time to time, to disengage the resinous matter which subsided. When the digestion was finished, the liquor was filtered, the residue carefully separated, and the water evaporated to the consistence of an extract.

If the salt be required to be separated, the evaporation must be suspended when the fluid is reduced to one pint. An earthy salt falls down by cooling, which is of a ruddy appearance, and has the form of scales mixed with needled crystals.

By this long but judicious process, the oil is first separated; which after three or four days rises to the surface of the liquor, where it forms an adhesive pellicle, like turpentine. This pellicle is gradually dissipated, and disappears at the end of a month, nothing more being seen than a few drops from time to time. In proportion as the oil is dissipated, the resin, which formed a soap with it, is precipitated.

Mr. Baumé has calculated that these principles exist in the following proportions:—Four pounds of common opium afford one pound once ounce of marc or insoluble matter, one pound fifteen ounces of extract, twelve ounces of resin, one gros or dram of salt, three ounces seven gros of dense oil or aroma.

Mr. Bucquet proposed to extract the sedative principle, by dissolving it in the cold, and afterwards evaporating it; Mr. Joffe, by agitating it in cold water; Messrs. De Lassone and Cornette, by dissolving, filtering it several times, and always evaporating it to the consistence of an extract.

The sedative principle is a medicine of the greatest value, because it does not produce that drunkenness and stupor which are too commonly the effects of crude opium.

When

When a plant does not afford its juice by incision, this may happen either because the quantity is too small, or because its consistence is not sufficiently fluid, or because there is not a sufficiently perfect communication between the vessels of the plant to permit the flowing of all the juice. In these cases the desired effect may be produced either by simple mechanical pressure, as in extracting the juice of hypocistus and acacia; or by the assistance of water, which softens the texture of the vegetable, at the same time that it dissolves and carries off the juice.

Concerning Vegetable Juices extracted by Pressure.

The succulent vegetables afford their juice by simple pressure; and the method of performing this operation is nearly the same in all plants. When it is intended to extract the juice of a plant, it is washed, cut into small pieces, pounded in a marble mortar, put into a linen bag, and pressed in a press.

There are some ligneous plants, such as sage, thyme, and the lesser centaury, whose juices cannot be extracted without the addition of a small quantity of water; there are other very succulent plants, such as borage, bugloss, and
chicory,

chicory, whose juices are so viscid and mucilaginous, as not to pass through a cloth unless a small quantity of water be added during the pounding. Inodorous plants may likewise be left to macerate, in order to prepare them for the extraction of their juices. The vegetable juices may be clarified by simple repose, or by filtration; when very fluid, by white of egg, or animal lymph, boiled with them; and when the juices contain principles which may be evaporated, such as those of sage, balm, marjoram, &c. the vial which contains the juice is plunged in boiling water, after having closed it with a paper with a hole pierced through it; and when the juice is clarified, it is taken out, dipped in cold water, and decanted.

The juice of acacia is extracted from the same tree which affords gum arabic. The fruits of this tree are collected before they are ripe; then pounded, pressed, and the juice dried in the sun: it forms balls of a blackish brown internally, redder externally, and of an astringent taste.

A juice is prepared with unripe flocs, which is sold under the name of German Acacia, and does not differ much from that of Egypt.

The juice of hypocistus is extracted from a parasitical plant which grows on the cistus in the island of Crete. The fruit is pounded,
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the juice extracted by pressure, and thickened in the sun; it becomes black, and of a firm consistence.

These two last-mentioned juices are used in medicine as astringents.

SECTION IV.

Concerning such Principles as escape from
Vegetables by Transpiration.

VEGETABLES, being endued with digestive organs, throw off all such principles as cannot be assimilated by them; and when the functions of the vegetable are not favoured by such causes as facilitate them, the nutritive juices are rejected nearly unaltered. We shall here attend to three principal substances that exhale from vegetables, viz. air, water, and aroma.

ARTICLE I.

Concerning Oxygenous Gas afforded by Vegetables.

Dr. Ingenhoufz published, in the year 1779, Experiments upon Vegetables, in which he affirms that plants possess the property of emitting vital air when acted upon by the direct rays of the

the sun; and that they emit a very mephitic air in the shade, and during the night.

Doctor Priestley made known the same results at the same time, as well as Mr. Senebier of Geneva, who nevertheless did not publish a work on this subject until the year 1782, in which he admits, as a general principle, that plants suffer vital air to escape in the sun-shine: but he maintains that they do not produce mephitic air in the shade; and is of opinion that, if Dr. Ingenhousz obtained any, it arose from a commencement of putrefaction in the plant.

The simplest process for extracting this gas from vegetables, consists in immersing them under water, beneath an inverted glass vessel. It is then seen, when the sun acts on the plant, that small bubbles are emitted, which gradually grow larger; arise from the fibres of the leaf, and ascend to the surface of the fluid.

All plants do not afford gas with the same facility. There are some which emit it the moment the sun acts upon them; such are the leaves of the jacobæa, of lavender, and of some aromatic plants. In other plants the emission is slower; but in none later than seven or eight minutes, provided the sun's light be strong. The air is almost totally furnished by the inferior surface of the leaves of trees: it is not
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the same with herbs ; for these afford air from nearly the whole of their surface, according to Senebier.

The leaves afford more air when attached to the plant than when gathered ; and the quantity is likewise greater the fresher and sounder they are.

Young leaves afford but a small quantity of vital air ; those which are full grown afford more, and the more the greener they are. Leaves which are injured, yellow, or red, do not afford it.

Fresh leaves cut in pieces afford air ; and the oxygen gas is capable of being emitted without the plant being plunged under water, as is proved from the experiments of Mr. Senebier.

The parenchyma of the leaf appears to be the part which emits the air. The epidermis, the bark, and the white petals, do not afford air ; and in general it is only the green parts of plants which afford oxygenous gas. Green fruits afford air, but those which are ripe do not ; and the same is true of grain.

It is proved that the sun does not act in the production of this phenomenon as a body which heats. The emission of this gas is determined by the light ; and I have even observed that a strong light, without the direct
action

action of the sun's rays, is sufficient to produce this phenomenon.

It is proved, by the experiments of Mr. Sennebier, that an acid diluted in water increases the quantity of air which is disengaged, when the water is not too much acidulated; and in this case the acid is decomposed.

It has been observed that the conferva affords much vital air; as well as the green matter which is formed in water, and is supposed by Ingenhousz to be a collection of greenish insects.

Pure air is therefore separated from the plant by the action of light; and the excretion is stronger accordingly as the light is more vivid. It seems that light favours the work of digestion in the plant; and that the vital air, which is one of the principles of almost all the nutritive juices, more especially of water, is emitted, when it finds no substance to combine with in the vegetable. Hence it arises that plants whose vegetation is the most vigorous, afford the greatest quantity of air: and hence likewise it is that a small quantity of the acid mixed with the water favours the emission, and increases the quantity of oxygenous gas.

By this continual emission of vital air, the Author of nature incessantly repairs the loss which is produced by respiration, combustion, and

and the alteration of bodies, which comprehends every kind of fermentation and putrefaction; and in this manner the equilibrium between the constituent principles of the atmosphere is always kept up.

ARTICLE II.

Concerning the Water afforded by Vegetables.

Plants likewise emit a considerable quantity of water in the form of vapour, through their pores; and this excretion may be estimated as the most abundant. Hales has calculated that the transpiration of an adult plant, such as the *helianthus annuus*, was in summer seven times more considerable than that of man.

Guettard has observed that this excretion is always in proportion to the intensity of the light, and not of the heat; so that it is scarcely any during the night. The same philosopher has observed that the aqueous transpiration is more especially made from the upper surface of the leaf. The water which exhales from vegetables is not pure, but serves as the vehicle of the aroma; and even carries with it a small quantity of extractive matter, which causes it to corrupt so speedily.

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The immediate effect of the aqueous evaporation consists in maintaining a degree of coolness in the plant, which prevents its assuming the temperature of the atmosphere.

ARTICLE III.

Concerning the Aroma, or Spiritus Rector.

Each plant has its characteristic smell. This odorant principle was distinguished by Boerhaave by the name of Spiritus Rector, and by the moderns under the name of Aroma.

The aroma appears to be of the nature of gas, from its fineness, its invisibility, &c. The slightest heat is sufficient to expel it from plants. Coolness condenses it, and renders it more sensible; and on this account the smell of plants is much stronger in the morning and evening.

This principle is so subtile, that the continual emission of it from a wood or flower does not diminish its weight, even after a very considerable time.

The aroma is sometimes fixed in an extract, sometimes in an oil, and this last combination is the most usual. It even appears to constitute
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the volatile character of the essential or volatile oils.

The nature of the aroma appears to vary prodigiously; at least if we may judge by the organ of smell, which distinguishes several species. There are some which have a nauseous or poisonous effect on the animal economy. Ingenhoufz quotes an instance of the death of a young woman occasioned by the smell of lilies, in 1719; and the famous Triller reports the example of a young woman who died in consequence of the smell of violets, while another was saved by removing the flowers. Martinus Cromerus exhibits likewise an example of a bishop of Breslau who died by a similar cause.

The mancenille tree, which grows in the West Indies, emits very dangerous vapours. The humour which flows from this tree is so unwholesome, that if it drop on the hand it raises a blister.

The American plant lobelia longiflora produces a suffocating oppression in the breast of those who respire in its vicinity, according to Jacquin, Hortus Vindobonensis. The rhus toxicodendron emits so dangerous an exhalation, that Ingenhoufz attributes the return of a periodical

dical disorder, which attacked the family of the curate of Croffen in Germany, to a bench shaded by this tree, under which they had the custom of sitting. Every one knows the effects of musk and oriental saffron on certain persons; and the exhalation of the walnut-tree is considered as very unwholesome.

We may here mention the noxious property of those canes or reeds which in this country are used to cover roofs and dunghills, &c. Mr. Poitevin saw a man who was very ill on account of having handled these canes: the parts of generation were prodigiously swelled. A dog which had slept upon the reeds suffered in the same manner, and was affected in the same parts.

The method of extracting the aroma varies according to its volatility and affinities. It is in general soluble in water, alcohol, oils, &c. and these fluids are severally employed to extract it from plants which afford it.

When water or alcohol are used, they are distilled by a gentle heat, and the aroma comes over with them. Simple infusion may be used; and in this way the loss of a portion of the aroma is avoided.

Water charged with aroma is known by the name of the distilled water of the substance made

use of. The distilled water of inodorous or herbaceous plants does not appear to possess any virtue; and the apothecaries have long since decided the question, by substituting spring water in its place. Spirit of wine combined with the same principle, is known by the name of the spirit or quintessence of the vegetable.

When the aroma is very fugacious, such as that of lilies, jasmine, or tuberoſe, the flowers are put into a tin cucurbit with cotton steeped in oil of ben. The cotton and the flowers are disposed in alternate layers; the cucurbit is closed, and a gentle heat applied. In this manner the aroma is permanently combined with the oil.

These are the three methods used to retain the odorant principle. The art of the perfumer consists in applying them at pleasure to various substances.

Perfumes are either dry or liquid. Among the first we may place the sachets, or little perfumed bags, which contain either mixtures of aromatic plants, or aromas in their native state; the perfumed powders, which obtain their smell by a few drops of the solution of aroma; the pastilles or comfits which have sugar for their basis, &c.

Liquid perfumes most commonly consist of
aroma

aroma dissolved in water or alcohol; the various liqueurs, or scented spirituous cordial waters, are nothing else but the same solutions diluted with water, and sweetened with sugar.

For example, to make the eau divine, the bark of four citrons is taken, and put into a glass alembic, with two pounds of good spirit of wine, and two ounces of orange-flower water; after which, distillation is performed on the sand-bath. On the other hand, one pound and a half of sugar is dissolved in one pound and a half of water. The two liquors being mixed, become turbid; but, being left to stand, the result is an agreeable liquor.

To make the cream of roses, I take equal parts of rose water, spirit of wine à la rose, and syrup of sugar. I mix these three substances, and colour the mixture with the infusion of cochineal.

But it must be allowed that, in all perfumes which are a little complicated, the nose is the best chemist that can be consulted; and a good nose is as requisite and essential to a perfumer, as a strong head is to a geometer.

SECTION V.

Concerning the Alterations to which Vegetables are subject after they are deprived of Life.

THE same principles which maintain life in vegetables and animals, become the speediest agents of their destruction when dead. Nature seems to have entrusted the composition, maintenance, and decomposition of these beings to the same agents. Air and water are the two principles which maintain the life in living beings; but the moment they are dead they hasten their alteration and dissolution. The heat itself, which assisted and fomented the functions of life, concurs to facilitate the decomposition. Thus it is that the frosts of Siberia preserve bodies for several months; and that in our mountains they are kept for a long time on the snow, when it intercepts the carrying them to the place of interment.

We shall examine the action of these three agents, namely heat, air, and water; and we shall

shall endeavour to shew the power and effect of each before we shall attend to their combined action.

C H A P. I.

Concerning the Action of Heat upon Vegetable Substances.

THE distillation of plants by a naked fire is nothing but the act of decomposing them by means of simple heat. This process was for a long time the only method of analysis. The first chemists of Paris adopted it for the analysis of near one thousand four hundred plants: and it was not till the commencement of the present century that this labour was discontinued; a labour which did not seem to advance the science, since in this way the cabbage and hemlock afforded the same products.

It is clear that an analysis by the retort ought not to shew the principles of vegetation: for, not to mention that heat changes their nature, by becoming a constituent part of the principles

extracted; these principles themselves become mixed together, and we can never know their order or state while in the living plant. The action of the heat moreover causes the vegetable principles to react upon each other, and confounds the whole together. Whence it arises that all vegetables afford nearly the same principles; namely, water, an oil more or less thick, an acid liquor, a concrete salt, and a coal or caput mortuum more or less abundant.

Hales took notice that the distillation of vegetables afforded much air; and was even in possession of an apparatus to collect and measure it. But in our time the methods of collecting and confining the gases are simplified; and the hydro-pneumatic apparatus has proved that the substances are formed of a mixture of carbonic acid, hydrogen, and sometimes a little nitrogen.

The order in which the several products are obtained, and the characters they exhibit, lead us to the following observations:

1. The water which passes first is usually pure, and without smell; but when odorant plants are distilled, the first drops are impregnated with their aroma. These first portions of water consist of that which was superabundant, and impregnated the vegetable tissue.

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When the water of composition, or that which was in combination with the vegetable, begins to rise, it carries along with it a small quantity of oil, which colours it ; and some portions of a weak acid, afforded by the mucilage and other principles with which it existed in the saponaceous state. The phlegm likewise very often contains a small quantity of ammoniac : and this alkali appears to be formed in the operation itself ; for there are few plants which contain it in their natural state.

2. To the phlegm succeeds an oily principle, little coloured at first ; but, in proportion as the distillation advances, the oil which rises is thicker, and more coloured. They are all characterized by a smell of burning, and an acrid taste, that arise from the impression of the fire itself. These oils are most of them resinous, and the nitric acid easily inflames them. They may be rendered more fluid and volatile by repeated distillations.

3. In proportion as the oil comes over, there sometimes distils carbonate of ammoniac, which attaches itself to the sides of the vessels. It is usually soiled with an oil which colours it. This salt does not appear to exist ready formed in vegetables. Rouelle the younger proved that the plants which afford the most of it, such

as the cruciferous plants, do not contain it in their natural state. It is therefore found when its component parts are volatilized and reunited by the distillation.

4. All vegetables afford a very great quantity of gas by distillation; and their nature has an influence on the gaseous substances they afford. Those plants which abound with resin, afford much more hydrogenous gas; while such as abound with mucilage produce carbonic acid.

The mixture of these gases forms an air which is heavier than the common inflammable air, on which account it has been found very little adapted to aërostatic experiments.

The art of charring wood, or converting it into charcoal, is an operation nearly similar to the distillation we have just described. It consists in forming pyramids of wood, or cones truncated at their summit. The whole is covered with earth, well beaten, leaving a lower and upper aperture. The mass is then set on fire; and when the whole is well ignited, the combustion is stopped by closing the apertures through which the current of air passed. By this means the water, the oil, and all the principles of the vegetable, are dissipated, except the fibre. The wood in this operation loses three-fourths of its weight,
and

and one-fourth of its bulk. According to Fontana and Morozzo, it absorbs air and water as it cools. I am assured, from my experiments in the large way, that pit-coal desulphurated (coaked) acquires twenty-five pounds of water in the quintal by cooling; but the coal of wood did not appear to me to absorb more than fifteen or twenty. The futurbrand of the Icelanders is nothing but wood converted into charcoal by the lava which has surrounded it. —See Von Troil's Letters on Iceland.

The charcoal which is the residue of all these distillations, is a substance which deserves an attention more particularly because it enters into the composition of many bodies, and bears a very great part in their phenomena.

Charcoal is the vegetable fibre very slightly changed. It most commonly preserves the form of the vegetable which afforded it. The primitive texture is not only distinguishable, but serves likewise to indicate the state and nature of the vegetable which has afforded it. It is sometimes hard, sonorous, and brittle; sometimes light, spongy, and friable; and some substances afford it in a subtle powder, without consistence. The coal of oils and resins is of this nature.

Charcoal well made has neither smell nor
3 taste;

taste; and it is one of the most indecomposable substances we are acquainted with.

When dry, it is not changed by distillation in close vessels. But, when moist, it affords hydrogenous gas and carbonic acid; which proves the decomposition of the water, and the combination of one of its principles with the charcoal, while the other is dissipated. By successively moistening and distilling charcoal, it may be totally destroyed.

Charcoal combines with oxygen, and forms the carbonic acid; but this combination does not take place unless their action be assisted by heat. The charcoal which burns in a chaffing-dish exhibits this result; and we perceive two very immediate effects in this operation:—1. A disengagement of heat, afforded by the transition of the oxygenous gas to the concrete state. 2. A production of carbonic acid: it is the formation of this acid gas which renders it dangerous to burn charcoal in places where the current of air is not sufficiently rapid to carry off the carbonic acid as it is formed.

Well-made charcoal does not change by boiling in water. In process of time it gives a slight reddish tinge to that fluid which arises from the solution of the coaly residue of the oils
of

of the vegetable mixed with the coaly-residue of the fibre.

If the sulphuric acid be digested upon charcoal, it is decomposed; and affords carbonic acid, sulphureous acid, and sulphur.

The nitric acid, when concentrated, is decomposed with much greater rapidity; for if it be poured upon very dry powder of charcoal, it sets it on fire. This inflammation may be facilitated by heating the charcoal or the acid. If the fluid which arises in this experiment be collected, it is found to be carbonic acid, nitrous gas, and nitric acid. M. Proust has observed, that when the acid is poured into the middle of the charcoal, it does not take fire; but that this effect immediately succeeds if the acid be suffered to flow beneath the coal. It may even be inflamed by throwing it upon the nitric acid slightly heated.

If weak nitric acid be digested upon charcoal, it dissolves it, assumes a red colour, becomes pasty, and acquires a bitter disagreeable taste.

Charcoal, mixed with the sulphuric and nitric salts, decomposes them; when combined with oxides, it revives the metals. All these effects depend on its very great affinity with the oxigene contained in these bodies. It is used to facilitate the decomposition of salt-petre

in

in some cases, as in the composition of gunpowder, the black flux, &c.

Rouelle has observed that the fixed alkali dissolves a good quantity of charcoal by fusion. The same chemist has discovered that the sulphur of alkali dissolves it in the humid as well as the dry way.

Charcoal is likewise capable of combining with metals. It combines with iron in its first fusion, and mixes with it likewise in the cementation by which steel is formed. When combined with iron in a small proportion of the metal, it constitutes plumbago. It is likewise capable of combining with tin by cementation; to which metal it gives brilliancy and hardness, as I find by experiment.

C H A P. II.

Concerning the Action of Water singly applied to Vegetables.

WE may consider the action of water upon vegetables in two very different points of view. Either the chemist applies this fluid

fluid to the plant itself, to extract and separate the juices from the ligneous part: or else the plant itself, being immersed in this fluid, is from this time delivered to its single action; and in that situation becomes gradually changed and decomposed in a peculiar manner. In these two cases, the products of the operations are very different. In the first, the ligneous texture remains untouched, and the juices which are separated remain unchanged in the fluid: in the second, more especially when vegetables ferment in heaps, the nature of the juices is partly changed, but the oils and resins remain confounded with the ligneous tissue; so that the result is a mass in which the disorganized vegetable is seen in a state of mixture and confusion of the various principles which compose it.

The chemist applies water to vegetables, to extract their juices, according to two methods, which constitute infusion and decoction.

Infusion is performed by pouring upon a vegetable a sufficient quantity of hot water to dissolve all its principles. The temperature of the water must be varied according to the nature of the plant. If its texture be delicate, or the aroma very fugacious, the water must be slightly heated; but boiling water may be used
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when the texture is hard and solid, and more especially when the plant has no smell.

Decoction, which consists in boiling water with the vegetable, ought not to be employed but with hard and inodorous plants. This method is rejected by many chemists, because they affirm that, by thus tormenting the plant, a considerable quantity of fibrous matter becomes mixed with the juices. Decoction is generally banished from the treatment of odorant plants, because it dissipates the volatile oil and aroma. The decoction used in our kitchens to prepare leguminous plants for food, has the inconvenience of extracting all the nutritive parts, and leaving only the fibrous parenchyma. Hence arises the advantage of the American pot or boiler, in which the garden-stuff is boiled by simple vapour, and consequently the nutritive principle remains in the vegetable; to which advantage we may add that of using any water whatever, because the steam alone is applied to the intended purpose.

But the infusion, decoction, and clarification of juices is not left to the choice of the chemist when it is required to prepare any medicine; for these methods produce surprising varieties in the virtue of remedies. Thus, for example, according to Storck, the concentrated juice of hemlock

hemlock has no good qualities unless it be evaporated without being clarified.

In treating juniper berries by infusion, and evaporation on a water bath to the consistence of honey, an aromatic extract is obtained, of a saccharine colour: the decoction of the same berries affords a less fragrant and less resinous extract, because the resin separates from the oil, and falls down.

The extract of grapes, which is called *resiné* in France, and most sweetmeats, are prepared in this way.

Extracts are prepared in the large way for sale by the assistance of water. We shall confine ourselves to speak of two only, the juice of liquorice and of cachou. The first will afford an example of decoction, and the second of infusion.

The extract of liquorice is prepared in Spain by decoction of the shrub of the same name. This plant grows abundantly near our ponds; and we might at a small expence avail ourselves of this species of industry: I have ascertained that a pound of this root affords two or three ounces of good extract. The apothecaries afterwards prepare it in various ways for their several purposes, and to render its use more convenient and agreeable.

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The cachou is extracted in the East Indies from an infusion of the seeds of a kind of palm. While the seed is yet green, it is cut, infused in hot water; and this infusion is evaporated to the consistence of an extract, which is afterwards made into lumps, and dried in the sun. M. de Jussieu communicated to the Academy, in the year 1720, remarks by which he ascertains that the differences in the several kinds of cachou arise from the various degrees of maturity in the seeds, and the greater or less quickness with which the extract is dried.

The cachou of commerce is usually impure; but it may be cleared of its impurities by dissolving, filtering, and evaporating it several times.

The taste of cachou is bitter and astringent. It dissolves very well in the mouth, and is used as a restorative for weak stomachs: it is made into comfits by the addition of three parts of sugar, and a sufficient quantity of gum adragant.

When vegetables are immersed in water, their texture becomes relaxed; all the soluble principles are carried off; and there remains only the fibrous part disorganized, and impregnated with vegetable oil, altered and hardened by the reaction of other principles. This transition
may

may be very well observed in marshes, where plants grow and perish in great numbers, forming mud by their decomposition. These strata of decomposed vegetables, when taken out of the water and dried, may be used as the material of combustion. The smell is unwholesome; but in shops, or places where the chimneys draw well, this combustible may be used.

Vegetables have been considered as the cause of the formation of pit-coal; but a few forests being buried in the earth, are not sufficient to form the mountains of coal which exist in its bowels. A greater cause, more proportioned to the magnitude of the effect, is required; and we find it only in that prodigious quantity of vegetables which grows in the seas, and is still increased by the immense mass of those which are carried down by rivers. These vegetables, carried away by the currents, are agitated, heaped together, and broken by the waves; and afterwards become covered with strata of argillaceous or calcareous earth, and are decomposed. It is easier to conceive how these masses of vegetables may form strata of coal, than that the remains of shells should form the greater part of the globe.

The direct proofs which may be given of the truth of this theory are—

1. The

1. The presence of vegetables in coal mines. The bamboo and banana trees are found in the coal of Alais. It is common to find terrestrial vegetables confounded with marine plants.

2. The prints of shells and of fish are likewise found in the strata of coal, and not unfrequently shells themselves. The pit-coal of Orsan and that of Saint-Esprit contain a prodigious number.

3. It is evidently seen, by the nature of the mountains which contain charcoal, that their formation has been submarine; for they all consist either of schistus, or grit, or lime-stone. The secondary schistus is a kind of coal in which the earthy principle predominates over the bituminous. Sometimes even this schistus is combustible, as is seen in that of St. George near Milhaud. The texture of the vegetables, and the impression of fish, are very well preserved in the schistus. The origin of the schistus is therefore submarine; and consequently so likewise must be the origin of the coal distributed in strata through its thickness.

The grit-stone consists of sand heaped together, carried into the sea by the rivers, and thrown up against the shores by the waves.

The

The strata of bitumen which are found in these cannot therefore but come from the sea,

Calcareous earth rarely contains strata of coal, but is merely impregnated with it, as at St. Ambroise, at Servas, &c. where the bitumen forms a cement with the calcareous earth.

Concerning Pit-Coal.

Pit-coal is usually found in strata in the earth, almost always in mountains of schistus or grit. It is the property of coal to burn with flame, and the emission of much smoke.

The secondary schistus is the basis of all pit-coal, and the quality of the coal mostly depends upon the proportion of this basis. When the schistus predominates, the coal is heavy, and leaves a very abundant earthy residue after its combustion. This kind of coal is veined internally with flat pieces, or rather separate masses, of schistus nearly pure, which we call *fiches*.

As the formation of the pyrites, as well as that of coal, arises from the decomposition of vegetable and animal substances, all pit-coal is more or less pyritous; so that we may consider pit-coal as a mixture of pyrites, schistus, and bitumen. The different qualities of coal arise therefore from the difference in the proportions of these principles.

When the pyrites is very abundant, the coal exhibits yellow veins of the mineral, which are decomposed as soon as they come in contact with the air; and form on efflorescence of sulphate of magnesia, of iron, of alumine, &c.

When pyritous coal is set on fire, it emits an insupportable smell of sulphur; but when the combustion is insensible, inflammation is frequently produced by the decomposition of the pyrites; and it is this which occasions the inflammation of several veins of coal. There are veins of coal on fire at St. Etienne in Forez, at Cramfac in Rouergue, at Roquecremade in the diocese of Beziers; and it is not rare to see the fire destroy considerable masses of pyritous coal, when the decomposition is favoured by the concurrence of air and water. If the inflammation be excited in more considerable masses of bitumen, the effects are then more striking; and it is to a cause of this nature that we ought to refer the origin and effect of volcanos.

When the schistus, or stony principle, predominates in coals, they are then of a bad quality, because their earthy residue is more considerable.

The best coal is that in which the bituminous principle is the most abundant, and exempt from all impurity. This coal swells up when
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it burns, and the fragments adhere together : it is more particularly upon this quality that the practice of the operation called desulphurating or purifying of coal depends. This operation is analogous to that in which wood is converted into charcoal. In the desulphuration, pyramids are made, which are set on fire at the centre. When the heat has strongly penetrated the mass, and the flame issues out of the sides, it is then covered with moist earth : the combustion is suffocated, the bitumen is dissipated in smoke, and there remains only a light spongy coal, which attracts the air and humidity, and exhibits the same phenomena in its combustion as the coal of wood. When it is well made, it gives neither flame nor smoke ; but it produces a stronger heat than that of an equal mass of native coal. This operation received the name of desulphurating (*desoufrage*) from a notion that the coal was by this means deprived of its sulphur ; but it has been proved that all coals which are capable of this operation contain scarcely any sulphur.

It was for a long time supposed that the smell of pit-coal was unwholesome ; but the contrary is now proved. Mr. Venel has made many experiments on this subject, and is convinced that neither man nor animals are incommoded by this vapour. Mr. Hoffman relates that dis-

orders of the lungs are unknown in the villages of Germany where this combustible only is used. I think that coal of a good quality does not emit any dangerous vapour; but when it is pyritous its smell cannot but be hurtful.

The use of coal is generally applicable to the arts; and nature appears to have concealed these magazines of combustible matter, to give us time to repair our exhausted forests. These mines are very abundant and numerous in the kingdom of France. Our province contains many, and we have more than twenty which are in full work. Pit-coal is applied in England even to domestic uses, and this part of mineralogy is very much cultivated in that kingdom. Individuals have there undertaken the most considerable enterprizes in this way. The Duke of Bridgwater has made a canal, at Bridgwater, two thousand five hundred toises in length, to facilitate the working of the coal mines in Lancashire. It cost five millions of livres: part of it is carried under a mountain; and it passes successively under as well as over rivers and highways. In our province we are in want of roads only for the transportation of our coal; and Languedoc has not had the spirit to perform a work which a private individual has executed in England.

In Scotland, Lord Dundonald has erected
furnaces

furnaces in which the bitumen is disengaged from coal; and the vapours are received and condensed in chambers, over which he has caused a river to flow for the purpose of cooling them. These condensed vapours supply the English navy with as much tar as it requires. Becher, in his work intitled "Foolish Wisdom, or Wise Folly," printed at Franckfort in 1683, affirms that he succeeded in appropriating the bad turf of Holland, and the bad coal of England, to the common uses. He adds that he obtained tar superior to that of Sweden by a process similar to that of the Swedes. He affirms that he had made this known in England, and shewn it to the king.

Mr. Faujas has carried the process of the Scotch nobleman into execution at Paris. The whole consists in setting fire to the coal, and extinguishing it at the proper time, that the vapour may pass into chambers containing water for the purpose of condensing them. This tar appeared to be superior to that of wood.

Pit-coal likewise affords ammoniac by distillation, which is dissolved in water, while the oil floats above.

When coal is deprived by combustion of all the oil and other volatile principles, the earthy residue contains the sulphates of alumine, iron, magnesia,

magnesia, lime, &c. These salts are all formed when the combustion is slow ; but when it is rapid the sulphur is dissipated, and there remain only the aluminous, magnesian, calcareous, and other earths. The alumine most commonly predominates.

Naptha, petroleum, mineral pitch, and asphaltes, are only slight modifications of the bituminous oil so abundant in pit-coal. This oil, which the simple heat of the decomposition of the pyrites is sufficient to disengage from the coal, receives other modifications by the impression of the external air.

Petroleum, or the oil petrol, is the first alteration. This oil is found near volcanos, in the vicinity of coal mines, &c. We are acquainted with several springs of this petroleum. There is one at Gabian in the diocese of Beziers. It is carried out by the water of a spring which issues from the lower part of a mountain whose summit is volcanized.

The smell of petroleum is disagreeable: its colour is reddish ; but it may be rendered clear by distilling it from the clay of Murviel.

Naptha is merely a variety of petroleum.

Near Derbens, on the Caspian Sea, there are springs of naptha, which Kempfer visited about a century ago, and of which he has left a description.

There

There is a place known by the name of the Perpetual Fire, where the fire burns without ceasing. The Indians do not attribute the origin of this inextinguishable fire to naptha; but they maintain that God has confined the Devil in this place, to deliver man from him. They go in pilgrimage thither, and make their prayers to God that he will not suffer this enemy of mankind to escape.

The earth impregnated with naptha is calcareous, and effervesces with acids; it takes fire by the contact of any ignited body whatever.

This perpetual fire is of great use to the inhabitants of Baku. They pare off the surface of this burning soil, upon which they make a heap of limestones, and cover it with the earth pared off; and in two or three days the lime is made.

The inhabitants of the village of Frogann repair to this place to cook their provisions.

The Indians assemble from all parts to adore the Eternal Being in this place. Several temples were built, one of which is still in existence. Near the altar there is a tube inserted in the earth, two or three feet in length; out of which issues a blue flame, mixed with red. The Indians prostrate themselves before this tube, and put themselves into attitudes which are exceedingly strange and painful.

Mr. Gmelin observes that two kinds of *naphtha* are distinguished in this country; the one transparent and yellow, which is found in a well. This well is covered with stones smeared with a cement of fat earth, in which the name of Kan is engraved; and no one is permitted to break this sealed covering but those who are deputed from the Kan.

Mineral pitch is likewise a modification of petroleum. It is found in Auvergne, at a place called Puits de Lapege, near Alais, in an extent of several leagues, which comprehends Servas, Saint Ambroise, &c.

The calcareous stone is impregnated with a bitumen which is softened by the heat of summer, when it flows from the rocks, and forms a very beautiful stalactites. It forms masses in the fields, and impedes the passage of carriages: the peasants use it to mark their sheep. This stone emits an abominable smell when rubbed. The episcopal palace of Alais was paved with it in the time of Mr. Davejan; but it became necessary to substitute other stone in its stead. It is asserted that mineral pitch was used to cement the walls of Babylon.

Asphaltes, or bitumen Judaicum, is black, brilliant, ponderous, and very brittle.

It emits a smell by friction; and is found floating

floating on the water of the lake Asphaltites, or the Dead Sea.

The asphaltes of commerce is extracted from the mines of Annemore, and more particularly in the principality of Neufchatel. Mr. Pallas found springs of asphaltes on the banks of the Sock, in Prussia.

Most naturalists consider it as amber decomposed by fire.

Asphaltes liquefies on the fire, swells up, and affords flame, with an acrid disagrecable smoke.

By distillation it affords an oil resembling petroleum. The Indians and Arabs use it instead of tar, and it is a component part of the varnish of the Chinese.

Yellow amber, karabe, or the electram of the ancients, is in yellow or brown pieces, transparent or opaque, capable of a polish, becoming electric by friction, &c.

It is friable and brittle.

There is no substance on which the imagination of poets has been more exercised than this. Sophocles had affirmed that it was formed in India by the tears of the sisters of Meleager, changed into birds, and deploring the fate of their brother; but one of the most interesting fabulous origins which have been attributed to it, is afforded by the fable of Phaeton burning the
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the heavens and the earth, and precipitated by the thunder of Jove into the waters of Eridanus. His sisters are described weeping; and the precious tears fell into the waters without mixing with them, became solid without losing their transparency, and were converted into the yellow amber so highly valued by the ancients. —See Bailly.

Amber possesses less coaly matter than any other bitumen.

It is frequently found dispersed over strata of pyritous earth, and covered with a stratum of wood, abounding with a blackish bituminous matter.

It is found floating in the Baltic Sea, on the coast of Ducal Prussia; it is also found near Sistreron in Provence.

No other chemical use was for a long time made of amber, than to form compositions for medicine and the arts. We are indebted to Neumann, Bourdelin, and Pott, for a tolerably accurate analysis of this bitumen. The two constituent principles exhibited in the analysis of amber, are the salt of amber or succinic acid, and a bituminous oil.

To extract the succinic acid, the amber is broken into small pieces, which are put into a retort, and distilled with a suitable apparatus upon

upon a sand bath. When the fire is carefully managed, the products are—1. An insipid phlegm. 2. Phlegm holding a small portion of acid in solution. 3. A concrete acid salt, which attaches itself to the neck of the retort. 4. A brown and thick oil, which has an acid smell.

The concrete salt always retains a portion of oil* in its first distillation. Scheffer, in his *Lessons of Chemistry*, proposes to distil it with sand; Bergmann with white clay; Pott advises solution in water, and filtration through white cotton; after which the fluid is to be evaporated, and is found to be deprived of the oil, which remains on the cotton. Spielmann, after Pott, proposes to distil it with the muriatic acid; it then sublimes white and pure. Bourdelin clears it of its oil by detonation with nitre. This salt is prepared in the large way at Koningsberg, where the shavings and chips of amber are distilled.

The succinic acid has a penetrating taste, and reddens the tincture of turnsole. Twenty-four parts of cold water, and two of boiling water, dissolve one of this acid. If a saturated solution of this salt be evaporated, it crystallizes in triangular prisms, whose points are truncated.

M. De Morveau observes that its affinities are barytes, lime, alkalis, magnesia, &c.

* *Acide* in the original: doubtless by oversight. T.

The oil of amber has an agreeable smell : it may be deprived of its colour by distillation from white clay. Rouelle distilled it with water. When mixed with ammoniac it forms a liquid soap, known by the name of Eau de Luce.

To make eau de luce, I dissolve Punic wax in alcohol, with a small quantity of oil of amber; and on this I pour the pure volatile alkali.

Alcohol attacks amber, and acquires a yellow colour. Hoffman prepares this tincture by mixing the spirit of wine with an alkali.

The medical use of amber consists in burning it, and receiving the vapour on the diseased part. These vapours are strengthening, and remove obstructions. The oil of amber is applied to the same use. A syrup of amber is made with the spirit of amber and opium, which is used to advantage as a sedative anodyne medicine. The finest pieces of amber are used to make toys. Wallerius affirms that the most transparent pieces may be used to make mirrors, prisms, &c. It is said that the King of Prussia has a burning mirror * of amber one foot in diameter; and that there is a column of amber in the cabinet of the Duke of Florence ten feet high, and of a very fine lustre.

* So in the original; but the matter as well as the properties of this substance put it out of doubt that it should be *lens*. T.

Concerning Volcanos.

The combustion of these enormous masses of bitumen which are deposited in the bowels of the earth, produces volcanos. They owe their origin more especially to the strata of pyritous coal. The decomposition of water upon the pyrites determines the heat, and the production of a great quantity of hydrogenous gas, which exerts itself against the surrounding obstacles, and at length breaks them. This effect is the chief cause of earthquakes; but when the concurrence of air facilitates the combustion of the bitumen and the hydrogenous gas, the flame is seen to issue out of the chimneys or vents which are made: and this occasions the fire of volcanos.

There are many volcanos still in an active state on our globe, independent of those of Italy, which are the most known. The abbé Chappe has described three burning in Siberia. Anderson and Von Troil have described those of Iceland. Asia and Africa contain several: and we find the remains of these fires or volcanic products in all parts of the globe.

Naturalists inform us that all the southern islands have been volcanized; and they are seen daily to be formed by the action of these subterraneous

terraneous fires. The traces of fire exist even immediately around us. The single province of Languedoc contains more extinct volcanos than twenty years ago were known to exist through all Europe. The black colour of the stones, their spongy texture, the other products of fire, and the identity of these substances with those of the volcanos at present burning, are all in favour of the opinion that their origin was the same.*

When

* A volcano was announced and described to be burning in Languedoc, respecting which it is necessary to give some elucidation. This pretended volcano is known by the name of the Phosphorus of Venejan.

Venejan is a village situated at the distance of a quarter of a league from the high road between St. Esprit and Bagnols. From time immemorial, at the return of spring, a fire was seen from the high road, which increased during the summer, was gradually extinguished in autumn, and was visible only in the night. Several persons had at various times directed their course from the high road, in a right line towards Venejan, to verify the fact upon the spot; but the necessity of descending into a deep valley before they could arrive thither, occasioned them to lose sight of the fire; and on their arrival at Venejan no appearance was seen in the least resembling the fire of a volcano. Mr. de Genffane describes this phenomenon, and compares it to the flashing of a strong aurora borealis: he even says that the country is volcanic. *Hist. Nat. du Languedoc, Diocese D'Uzes.*—At length, in the course of the last four or five years, it was observed that these fires were multiplied

When the decomposition of the pyrites is advanced, and the vapours and elastic fluids can no longer be contained in the bowels of the earth, the ground is shaken, and exhibits the phenomena of earthquakes. Mephitic vapours are multiplied on the surface of the ground,

multiplied in the spring; and that, instead of one, there were three. Certain philosophers of Bagnols undertook the project of examining this phenomenon more closely; and for this purpose they repaired to a spot between the high road and Venejan, armed with torches, speaking trumpets, and every other implement which they conceived to be necessary for making their observations. At midnight, four or five of the party were deputed and directed towards the fire; and those who remained behind directed them constantly in their way by means of their speaking trumpets. They at last arrived at the village, where they found three groups of women winding silk in the middle of the street by the light of a fire made of hemp stalks. All the volcanic phenomena then disappeared, and the explanation of the observations made on this subject became very simple. In the spring, the fire was weak, because it was fed with wood, which afforded heat and light; during the summer, hemp stalks were burned, because light only was wanted. At that time there were three fires, because the fair of Saint Esprit was near at hand, at which they sold their silk, and which consequently put them under the necessity of expediting their work. As these observers announced their arrival with much noise, the country people drove them back by a shower of stones, which the Don Quixotes of natural history might have taken for a volcanic eruption.

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and dreadful hollow noises are heard. In Iceland, the rivers and springs are swallowed up; a thick smoke, mixed with sparks and lightning, is then disengaged from the crater; and naturalists have observed that, when the smoke of Vesuvius takes the form of a pine, the eruption is near at hand.

To these preludes, which shew the internal agitation to be great, and that obstacles oppose the issue of the volcanic matters, succeeds an eruption of stones and other products, which the lava drives before it; and lastly appears a river of lava, which flows out, and spreads itself down the side of the mountain. At this period the calm is restored in the bowels of the earth, and the eruption continues without earthquakes. The violent efforts of the included matter sometimes cause the sides of the mountain to open; and this is the cause which has successively formed the smaller mountains which surround volcanos. Montenuovo, which is a hundred and eighty feet high, and three thousand in breadth, was formed in a night.

This crisis is sometimes succeeded by an eruption of ashes which darken the air. These ashes are the last result of the alteration of the coals; and the matter which is first thrown out
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is that which the heat has half vitrified. In the year 1767, the ashes of Vesuvius were carried twenty leagues out to sea, and the streets of Naples were covered with them. The report of Dion, concerning the eruption of Vesuvius in the reign of Titus, wherein the ashes were carried into Africa, Egypt, and Syria, seems to be fabulous. Mr. de Saussure observes that the soil of Rome is of this character, and that the famous catacombs are all made in the volcanic ashes.

It must be admitted, however, that the force with which all these products are thrown, is astonishing. In the year 1769, a stone twelve feet high, and four in circumference was thrown to the distance of a quarter of a mile from the crater: and in the year 1771 Sir William Hamilton observed stones of an enormous size, which employed eleven seconds in falling.

The eruption of volcanos is frequently aqueous: the water, which is confined, and favours the decomposition of the pyrites, is sometimes strongly thrown out. Sea salt is found among the ejected matter, and likewise sal ammoniac. In the year 1630, a torrent of boiling water, mixed with lava, destroyed Portici and Torre del Greco. Hamilton saw boiling water eject-

ed. The springs of boiling water in Iceland, and all the hot springs which abound at the surface of the globe, owe their heat only to the decomposition of pyrites.

Some eruptions are of a muddy substance; and these form the tufa, and the puzzolano. The eruption which buried Herculaneum is of this kind. Hamilton found an antique head, whose impression was well enough preserved to answer the purpose of a mould. Herculaneum, at the least depth, is seventy feet under the surface of the ground, and often at one hundred and twenty.

The puzzolano is of various colours. It is usually reddish; sometimes gray, white, or green: it frequently consists of pumice stone in powder; but sometimes it is formed of calcined clay. One hundred parts of red puzzolano afforded Bergmann, silica 55, alumina 20, lime 5, iron 20,

When the lava is once thrown out of the crater, it rolls in large rivers down the side of the mountain to a certain distance, which forms the currents of lava, the volcanic causeways, &c. The surface of the lava cools and forms a solid crust, under which the liquid lava flows. After the eruption, this crust sometimes remains, and forms hollow galleries, which

which Messrs. Hamilton and Ferber have visited: it is in these hollow places that the sal ammoniac, the marine salt, and other substances, sublime. A lava may be turned out of its course by opposing banks or dikes against it: this was done in 1669, to save Catania; and Sir William Hamilton proposed it to the king of Naples, to preserve Portici.

The currents of lava sometimes remain several years in cooling. Sir William Hamilton observed, in 1769, that the lava which flowed in 1766 was still smoking in some places.

When the current of lava is received by water, its cooling is quicker; and the mass of lava shrinks so as to become divided into those columns which are called basaltcs. The famous Giants' Causeway is the most astonishing effect of this kind which we are acquainted with. It exhibits thirty thousand columns in front, and is two leagues in length along the sea coast. These columns are between fifteen and sixteen inches in diameter, and from twenty-five to thirty feet long.

The basaltcs are divided into columns of four, five, six, and seven sides. The emperor Vespasian made an entire statue, with sixteen children, out of a single column of basaltcs,

which he dedicated to the Nile, in the Temple of Peace.

Basaltcs afforded Bergmann, per quintal, silica 56, alumine 15, lime 4, iron 25.

Lava is sometimes swelled up and porous. The lightest is called pumice-stone.

The substances thrown out by volcanos are not altered by fire. They eject native substances, such as quartz, crystals of amethyst, agate, gypsum, amianthus, feld-spar, mica, shells, schorl, &c.

The fire of volcanos is seldom strong enough to vitrify the matters it throws out. We know only of the yellowish capillary and flexible glass thrown out by the volcanos of the island of Bourbon on the fourteenth of May 1766 (M. Commerfon), and the lapis gallinaceus ejected by Hecla. Mr. Egoifrijoufon, who is employed by the Observatory at Copenhagen, has settled in Iceland, where he uses a mirror of a telescope which he has made out of the black agate of Iceland.

The slow operation of time decomposes lavas, and their remains are very proper for vegetation. The fertile island of Sicily has been every where volcanized. I observed several ancient volcanos at present cultivated; and the line which separates the other earths from
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the volcanic earth, constitutes the limit of vegetation. The ground over the ruins of Pompeia is highly cultivated. Sir William Hamilton considers subterranean fires as the great vehicle used by nature to extract virgin earth out of the bowels of the globe, and repair the exhausted surface.

The decomposition of lava is very slow. Strata of vegetable earth, and pure lava, are occasionally found applied one over the other; which denote eruptions made at distances of time very remote from each other, since it requires nearly two thousand years before lava receives the plough. An argument has been drawn from this phenomenon to prove the antiquity of the globe: but the silence of the most ancient authors concerning the volcanos of our kingdom, of which we find such frequent traces, proves that these volcanos have been extinguished from time immemorial; a circumstance which carries their existence to a very distant period. Besides this, several thousand years of connected observations have not afforded any remarkable change in Vesuvius or Etna; nevertheless, these enormous mountains are all volcanized, and consequently formed of strata applied one upon the other. The prodigy becomes much more striking, when

when we observe that all the surrounding country, to very great distances, has been thrown out of the bowels of the earth.

The height of Vefuvius above the level of the sea is three thousand six hundred and fifty-nine feet ; its circumference thirty-four thousand four hundred and forty-four. The height of Etna is ten thousand and thirty-six feet ; and its circumference one hundred and eighty thousand,

The various volcanic products are applicable to several uses.

1. The puzzolano is of admirable use for building in the water ; when mixed with lime, it speedily fixes itself ; and water does not soften it, for it becomes continually harder and harder. I have proved that calcined ochres afford the same advantage for this purpose ; they are made into balls, and baked in a potter's furnace in the usual manner. The experiments made at Sette, by the commissary of the province, prove that they may be substituted with the greatest advantage, instead of the puzzolano of Italy.

2. Lava is likewise susceptible of vitrification ; and in this state it may be blown into opaque bottles of the greatest lightness, as I have done at Erepian and at Alais. The very
hard

hard lava, mixed in equal parts with wood ashes and soda, produced an excellent green glass. The bottles made of it were only half the weight of common bottles, and much stronger; as was proved by my experiments, and those which Mr. Joly de Fleury ordered to be made under his administration.

3. Pumice stone likewise has its uses; it is more especially used to polish most bodies which are somewhat hard. It is employed in the mass or in powder, according to the intended purpose. Sometimes, after levigation, it is mixed with water to render it softer.

C H A P. III.

Concerning the Decomposition of Vegetables in the Bowels of the Earth.

HERBACEOUS plants, buried in the earth, are slowly decomposed; but the waters which filter through and penetrate them relax their texture. The salts are extracted; and they become converted into a stratum of blackish matter, in which the vegetable texture

is

is still discernible. These strata are sometimes perceived in digging into the earth. But this alteration is infinitely more perceptible in wood itself, than in herbaceous plants. The ligneous body of a tree buried under the ground becomes of a black colour, more friable, and breaks short; the fracture is shining; and the whole mass appears, in this state, to form an uniform substance, capable of the finest polish. The wood thus changed is called Jet. In the environs of Montpellier, near St. Jean de Cucule, several cart loads of trunks of trees have been dug up, whose form was perfectly preserved, but which were converted into jet. I have myself found a wooden peal converted into jet. In the works at Nismes pieces of wood were found entirely converted into the state of jet. In the neighbourhood of Vachery, in Gevaudan, a jet is found, in which the texture of the walnut-tree is very discernible. The texture of the beech is seen in the jet of Bofrup in Scania. In Guelbre a forest of pines has been discovered buried beneath the sand; and at Beichlitz two strata of coal are wrought, according to Mr. Jars, the one bituminous, and the other of fossil wood. I preserve in the cabinet of mineralogy of Languedoc, several pieces of wood, whose external part is in the
2 state

state of jet, while the internal part still remains in the ligneous state; so that the transition from the one to the other may be observed.

Jet is capable of receiving the most perfect polish. It is made into toys, such as buttons, snuff-boxes, necklaces, and other ornaments. It is wrought in Languedoc, near Saint Colombe, at the distance of three leagues from Castelnaudray. It is ground down, and cut into facets, by mills.

Jet softens in the fire, and burns with the emission of a fetid odour. It affords an oil which is more or less black, but may be rendered colourless by repeated distillations from the earth of Murviel.

C H A P. IV.

Concerning the Action of Air and Heat upon Vegetables.

WHEN heat is applied to a vegetable exposed to the air, certain phenomena are produced, which depend on the combination

nation of pure air with the inflammable principles of the plant; and this is combustion.

In order to produce a commencement, a heated body is applied to the dry wood which is intended to be set on fire. By this means the principles are volatilized in the same order as we have pointed out in the preceding article. A smoke is produced, which is a mixture of water, oil, volatile salts, and all the gaseous products which result from the combination of vital air with the several principles of the vegetable. The heat then increases by the combination of the air itself, because it passes to the concrete state; and when this heat is carried to a certain point, the vegetable takes fire, and the combustion proceeds until all the inflammable principles are destroyed.

In this operation there is an absorption of vital air, and a production of heat and light. The combustion will be stronger in proportion as the inflammable principle is more abundant, as the aqueous principle is less abundant, as the wood is more resinous, and as the air is purer and more condensed.

The disengagement of heat and light is more considerable, accordingly as the combination of vital air is stronger in a given time.

The residues of combustion consist of substances

stances which are volatilized, and fixed substances; the one forms the soot, the other the ashes.

The soot partly arises from substances imperfectly burned, decomposed only in part, which have escaped the action of vital air. Hence it is that the soot may be burned over again; and hence likewise it is that, when the combustion is very rapid and effectual, there is no perceptible smoke; because all the inflammable matter is then destroyed, as in the cylinder lamps, violent fires, &c.

The analysis of soot exhibits an oil which may be extracted by distillation; a resin which may be taken up by alcohol, and which arises either from the imperfect alteration of the resin of the vegetable, or the combination of vital air with the volatile oil. It likewise affords an acid, which is often formed by the decomposition of mucus; and it is this acid, of great utility in the arts, for which the Academy of Stockholm has described a furnace proper for collecting it. Soot likewise affords volatile salts, such as the carbonate of ammoniac, and others. A slight portion of fibrous matter is likewise volatilized by the force of the fire, and we find it again in the soot.

The fixed principle remaining after combustion,

tion, forms the ashes. They contain salts, earths, and metals, of which we have already treated. The salts are fixed alkalis, sulphates, nitrates, muriates, &c. the metals are iron, gold, manganese, &c. and the earths are alumine, lime, silica, and magnesia.

C H A P. V.

Concerning the Action of Air and Water, which determine a Commencement of Fermentation that separates the Vegetable Juices from the Ligneous Part.

WHEN the decomposition of vegetables is facilitated by the alternate action of air and water, their organization becomes destroyed; the connection between the various principles is broken; the water carries away the juices, and leaves the fibrous skeleton naked, sufficiently coherent, and sufficiently abundant in certain vegetables, to be extracted in this way. Hemp is prepared in this manner. The abbé Rozier attributes the advantage of watering to the fermentation of the mucilaginous

ginous part. M. Prozet has proved that hemp contains an extractive and a resinous part; and that the watering destroys the former, and the second is detached almost mechanically. It has been observed that the addition of a small quantity of alkali favours this operation.

Running water is preferable to standing water; because standing water keeps up addevelopes a stronger fermentation, which attacks the ligneous part. It has been observed that flax prepared in running water is whiter and stronger than that which is prepared in standing water. The stagnant water has likewise the inconvenience of emitting an unpleasant smell, pernicious to the animal œconomy. The addition of alkali corrects and prevents this effect.

In the diocese of Lodeve, the young shoots of the Spanish genet are prepared by a very simple process. It is sown on the high grounds, where it is left for three years; at the end of which time the sprigs or young shoots are cut, and formed into bundles, which are sold from twelve to fifteen sous each. The first operation consists in crushing them with a beetle. The following day they are laid in a running stream, with stones upon them, to prevent their being washed away. In the evening they are taken out, and laid in a heap on the banks of the river, upon
straw

straw or fern, covering them with the same, and loading the heap with stones : this operation they call *mettre à couvert*. Every evening they throw water on the heap. At the end of eight days they open the mafs, and find that the bark is easily separated from the wood. They take the packets, one after the other, and beat and rub them strongly with a flat stone, till the epidermis of the extremities is well cleared off, and the whole stem becomes white. It is then hung to dry ; and the bark which was separated from the ligneous substance, is carded and spun, and made into very useful cloth. The peasants are acquainted with no other linen for cloths, sacks, shirts, &c. Every one prepares his own, none being made for sale.

The genet, *genista juncea*, has likewise the advantage of affording a green food to cattle during the winter ; at the same time that it supports the earth by its roots, and prevents its being carried down into the valleys. The bark of the mulberry tree may be treated in the same manner. Olive de Serres has described a good process for this purpose.

It is the skeleton formed by the vegetable fibre only, and deprived of all foreign matter, which is used to make cloth ; it is the most incorruptible principle of vegetation : and when
this

this fibre, being converted into cloth, can no longer be used as such, it is subjected to extreme division, to convert it into paper. The operations for this purpose are the following:—The rags are cleaned, and laid in water to rot; after which they are torn by hooked pestles moved by water: the second pestles under which they are made to pass, are not armed with hooks like the first, but merely with round nails: the third are of wood only. By this means the rags are converted into a paste, which is attenuated still more by boiling. This paste is received in wire moulds, dried, and forms blotting paper. Writing paper is dipped in size, and sometimes glazed.

C H A P. VI.

Concerning the Action of Air, of Heat, and of Water upon Vegetables.

WHEN the various juices of vegetables are diffused in water, and the action of this fluid is favoured by the combined action of air

air and heat, a decomposition of these juices ensues. The oxygenous gas may be considered as the first agent of fermentation: it is afforded either by the atmosphere, or by the water which is decomposed.

It was from an observation of these facts that Becher thought himself authorized to consider fermentation as a kind of combustion:—"Nam combustio, seu calcinatio per fortem ignem, licet putrefactionis species, eidemque analoga sit—fermentatio ergo definitur, quod sit corporis densioris rarefactio, particularumque æreæ rarioris interpositio, ex quo concluditur debere in aëre fieri, nec nimium frigido nec nimium calido, ne partes raribiles expellantur, in aperto tamen vase, vel tantum vacuo ut partes rarefieri queant; nam stricta closura, et vasis impletio, fermentationem totaliter impedit."—Becher, *Phys. Subst. f. i. 15, v. cap. 11, p. 313.*

The conditions necessary for the establishment of fermentation are—1. The contact of pure air. 2. A certain degree of heat. 3. A quantity of water more or less considerable, which produces a difference in the effects.

The phenomena which essentially accompany fermentation are—1. The production of heat. 2. The absorption of oxygenous gas.

Fermentation may be assisted—1. By increasing

ing the mass of fermentable matter. 2. By using a proper leaven.

1. By increasing the fermentable mass, the principles on which the air must act are multiplied; consequently the action of this element is facilitated; more heat is therefore produced by the fixation of a greater quantity of air; and consequently the fermentation is promoted by the two causes which most eminently maintain it, heat and air.

2. Two kinds of leaven may be distinguished.

1. Bodies eminently putrescible, the addition of which hastens the fermentation. 2. Those which already abound with oxigene, and which consequently afford a greater quantity of this principle of fermentation. This effect is produced by the inhabitants of the banks of the Rhyn, by throwing fresh meat into the vintage, to hasten the spirituous fermentation (Linné *Amœnit. Acad. Differt. de Genesi Calculi*): and so likewise the Chinese throw excrements into a kind of beer, made of a decoction of barley and oats. And on this account it is that the acids, the neutral salts, chalk, rancid oils, and the metallic calces, &c. hasten fermentation.

The products of fermentation have caused different species to be distinguished: but this variety of effects depends on the variety of

principles in the vegetable. When the saccharine principle predominates, the result of the fermentation is a spirituous liquor ; when, on the contrary, the mucilage is most abundant, the product is acid ; if the gluten be one of the principles of the vegetable, there will be a production of ammoniac in the fermentation : so that the same fermentable mass may undergo different alterations, which always depend on the nature and respective properties of the constituent principles, the susceptibility of change, &c. Thus a saccharine liquid, after having undergone the spirituous fermentation, may be subjected to the acid fermentation, by the decomposition of the mucilage which had resisted the first fermentation : but in all cases the concurrence of air, water, and heat, is necessary to develop fermentation. We shall therefore confine ourselves to the examination of these three agents : 1. On the juices extracted from vegetables, and diffused in water, which constitutes the spirituous and acid fermentations : 2. On the vegetable itself, which will lead us to the formation of vegetable mould, ochres, &c.

ARTICLE I.

Concerning the Spirituous Fermentation and its Products.

That fermentation is distinguished by the name of Spirituous, which affords ardent spirit, or alcohol, as its product or result.

It may be considered as a fundamental principle, that no substances are capable of this fermentation but saccharine bodies. Pure sugar mixed with water forms taffia, or rum, by fermentation, and we find this principle in the analysis of all the bodies which are susceptible of it.

In order to develop this fermentation, there is required, 1. The access of air. 2. A degree of heat between ten and fifteen of Reaumur. 3. The division and expression of the juice contained in the fruits, or in the plant. 4. A mass or volume somewhat considerable.

We will make the application of these principles to the fermentation of grapes. When these are ripe, and the saccharine principle is developed, they are then pressed, and the juice which flows out is received in vessels of a proper capacity, in which the fermentation appears, and proceeds in the following manner:—

At the end of several days, and frequently after a few hours, according to the heat of the atmosphere, the nature of the grapes, the quantity of the liquid, and the temperature of the place in which the operation is performed, a movement is produced in the liquor, which continually increases; the volume of the fluid increases; it becomes turbid and oily; carbonic acid is disengaged, which fills all the unoccupied part of the vessel, and the temperature rises to the 18th degree. At the end of several days these tumultuous motions subside, the mass falls, the liquor becomes clearer, and is found to be less saccharine, more odorant, and of a red colour, from the reaction of the ardent spirit upon the colouring matter of the pellicle of the grape*.

The causes of an imperfect fermentation are the following: 1. If the heat be too little, the fermentation languishes, the saccharine and oily matters are not sufficiently elaborated, and the wine is unctuous and sweet.

2. If the saccharine body be not sufficiently

* Richardson, in his Treatise on Brewing, insists much on the difference between the specific gravity of the fluid before and after fermentation, which he considers as proportional to the strength or inebriating quality of the fluid. Fermented liquors have a less specific gravity than they possessed before the fermentation. This circumstance well deserves the attention of the manufacturer. T.

abundant,

abundant, as happens in rainy seasons, the wine is weak, and the mucilage which predominates causes it to become sour by its decomposition.

3. If the juice be too watery, concentrated and boiling must is added.

4. If the saccharine principle be not sufficiently abundant, the defect may be remedied by the addition of sugar. Macquer has proved that excellent wine may be made of verjuice and sugar; and Mr. De Bullion has made wine at Bellejames with the verjuice of his vine rows and moist sugar.

There have been many disputes to determine whether grapes should be pressed with the stalks or without. It seems to me that this depends on the nature of the fruit. When they are highly charged with saccharine and mucilaginous matter, the stalk corrects the insipidity of the wine by its bitter principle: but when, on the contrary, the juice is not too sweet, the stalk renders it drier, and very rough.

The wine is usually taken out of the fermenting vessels at the period when all the phenomena of fermentation have subsided. When the mass is settled, the colour of the liquor is well developed, when it has become clear, and its heat has disappeared; it is put into casks, where, by a second insensible fermentation, the wine

wine is clarified, its principles combine more perfectly together, and its taste and smell become more and more developed.

If this fermentation be stopped or suffocated, the gaseous principles are retained, and the wine is brisker, and more of the nature of must. Becher had very proper ideas of the effects of these two fermentations.

Distinguitur autem inter fermentationem apertam et clausam; in aperta potus fermentatus sanior est, sed debilior; in clausa non ita sanus, sed fortior; causa est quod evaporantia rarefacta corpuscula imprimis magna adhuc filvestrium spirituum copia, de quibus antea egimus, retineatur, et in ipsum potum se precipitet, unde valde eum fortem reddit. Becher, Phys. Subt. lib. 1, v. V. cap. 11, p. 313.

It appears, from the interesting experiments of the Marq. de Bullion, that the vinous fermentation does not take place unless tartar be present.

By evaporating the must of grapes, a salt is obtained, which has the appearance of tartar, and forms salt of Seignette with the alkali of soda. A large quantity of sugar is also obtained. For this purpose the tartar is first to be extracted; after which, the must having evaporated to the consistence of a thick syrup, is to be left for six months in a cellar. At the expiration of
this

this time, the sugar is found in a confused state of crystallization ; and this being washed with spirit of wine, to carry off the colouring part, becomes very fine and pure.

Wine deprived of its tartar ferments no more, and the fermentation is in proportion to the abundance of the tartar. Cream of tartar produces the same effect.

It appears that these salts act only as leavens, to facilitate the decomposition of the saccharine principle.

The juice of grapes is not the only vegetable fluid susceptible of the spirituuous fermentation.

Apples contain a juice which easily ferments, and produces cyder. Wild apples are usually employed for this purpose. These are bruised, and the juice pressed out, which ferments, and exhibits the same phenomena as the juice of grapes.

In order to have cyder fine, it is to be decanted off the lees as soon as the tumultuous fermentation has subsided, and it begins to be clear. Sometimes, in order to render it milder, a certain quantity of the juice of apples recently expressed is added, which produces a second fermentation in the cyder less strong than the first. The cyder which is left to stand on the lees acquires strength by that means. Cyder affords the same products as wine ; but the brandy

brandy obtained from it has a disagreeable flavour, because the mucilage, which is very abundant in the cyder, is altered by the action of the heat of distillation. But if it be cautiously distilled, it affords excellent brandy, according to the experiments of M. Darcet.

The juice of the hardest kind of pears affords, by fermentation, a kind of cyder called Perry.

Cherries likewise afford a tolerably good wine; and a kind of brandy is obtained from them, which the Germans call Kirchenwasser.

In Canada the fermentation of the saccharine juice of the maple affords a very good liquor; and the Americans, by fermenting the impure syrups of sugar with two parts of water, form a liquor which affords the spirit called Taffia, or Rum, by the English.

A drink called Beer is likewise prepared with certain grain; such as wheat, oats, and barley; but more especially with the latter. 1. The grain is made to sprout or vegetate, by steeping it in water, and placing it in a heap. By this means the glutinous principle is destroyed. 2. It is torrefied or stoved, to stop the progress of the fermentation, and fit it for the mill. 3. It is sifted, to separate the sprouts or radicles. 4. It is ground into a very coarse flour, named Malt. 5. The malt is infused in hot water, in
the

the mash-tub. This dissolves the sugar and the mucilage, and is called the first wort. It is then drawn off, heated, and again poured on the malt, which forms the second wort.*

6. This infusion, or wort, is boiled with a certain quantity of hops, which communicate an extractive resinous principle to it. 7. An acid leaven, or ferment, is added, and it is poured into a cooler, where it undergoes the spirituous fermentation. When the fermentation has subsided, it is stirred, and put into casks, where it continues to ferment, and throws off a frothy scum by the bung, which becomes sour, and serves as a ferment for future brewings, under the name of Yeast.

The product of all the substances is a liquor more or less coloured, capable of affording ardent spirit, by distillation, of an aromatic and resinous smell, a penetrating hot taste, which stimulates the action of the fibres.

Wine is an excellent drink, and is also used as the vehicle of certain medicines. Such are,

1. The emetic wine, which is prepared by di-

* In our breweries this practice is used only for double ales: and the strengths in other cases are regulated by the number of times the same malt is wetted, and the time of infusion. The third mashing affords small beer. T.

gesting two pounds of good white wine on four ounces of the crocus metallorum: 2. Chalybeated wine, made by digesting one ounce of steel filings in two pounds of white wine: 3. The wines in which plants are infused; such as wormwood, sorrel, and the liquid laudanum of Sydenham, which is made by digesting for several days two ounces of sliced opium, one ounce of saffron, one dram of pounded cinnamon and of cloves, in one pound of Spanish wine.

We shall proceed to examine the constituent principles of these spirituous liquors, by taking that of grapes for an example. The moment the wine is in the cask, a kind of analysis takes place, which is announced by the separation of some of its constituent principles; such as the tartar which is deposited at the sides, and the lees which are precipitated to the bottom: so that there remain only the ardent spirit and the colouring matter diffused in a volume of liquid, which is more or less considerable.

1. The colouring principle is of a resinous nature, and is contained in the pellicle of the grape; and the fluid is not coloured until the wine is formed; for until then there is nothing which can dissolve it: and hence it is that white wine may be made of red grapes, when the juice of the grape is expressed, and the husk thrown away.

If

If wine be evaporated, the colouring principle remains in the residue, and may be extracted by spirit of wine.

Old wines lose their colour, a pellicle being precipitated, which is either deposited on the sides of the bottles, or falls to the bottom. If wine be exposed to the heat of the sun during the summer, the colouring matter is detached in a pellicle, which falls to the bottom: when the vessel is opened, the discolouring is more speedy, and it is effected in two or three days during the summer. The wine thus deprived of its colour is not perceptibly weakened.

2. Wine is usually decomposed by distillation: and the first product of the operation is known by the name of Brandy.

Brandies have been made since the thirteenth century; and it was in Languedoc where this commerce first originated. Arnould de Ville-neuve appears to have been the author of this discovery. The alembics in which wine was distilled consisted for a long time of a kind of boiler, surmounted with a long cylindric neck, very narrow, and terminating in a hollow hemisphere, in which the vapours were condensed. To this small capital was adapted a narrow tube, to convey the fluid into the serpentine or worm pipe. This distillatory apparatus has been successively

cessively improved. The column has been considerably lowered; and the stills generally adopted for the distillation of wines in Languedoc are nearly of the following form. The body of the still is flat at bottom, and the sides rise perpendicularly to the height of twenty-one inches. At this height the sides incline inwards, so as to diminish the opening to twelve inches. This opening ends in a neck of several inches long, which receives the basis of a small covering called the head, which approaches to the figure of an inverted cone. From the angle of the upper base of the capital, there issues a small beak, intended to receive the vapours of brandy, and transmit them into the worm-pipe to which it is adapted. This worm-pipe has five or six turns, and is placed in a tub, which is kept filled with cold water, to condense the vapours.

The body of the still is usually surrounded by the masonry as high as the neck, and the bottom only is exposed to the immediate action of the fire. An ash-hole, which is too small, a fire-place large enough, and a chimney placed opposite the door of the fire-place, constitute the furnaces in which these stills are fixed.

The still is charged with between five and six quintals of wine; the distillation is made in
eight

eight or nine hours ; and from fixty to seventy-five pounds of pit-coal is consumed in each distillation.

Every judicious person must be aware of the imperfection of this apparatus. Its principal faults are the following :

1. The form of the body is such as to contain a column of wine of considerable height and little breadth, which being acted on by the fire at its base, is burned at that part before the upper part is heated.

2. The contraction of the upper part renders the distillation more difficult and slow. In fact, this inclined part being continually struck by the air, condenses the vapours, which incessantly return into the boiler. It likewise opposes the free passage of the vapours, and forms a kind of colipile, as Mr. Baumé has observed ; so that the vapours being compressed at this narrow neck, react on the wine, and oppose its further ascent.

3. The capital is not constructed in a more advantageous manner. The upper part becomes of the same temperature as the vapours, which cannot therefore be condensed, and, by their reaction, either suspend or retard the distillation.

4. In addition to this imperfect form of the apparatus,

apparatus, is joined the most disadvantageous method of administering the fire. The ash-hole is every where much contracted; the fire-place is very large, and the door shuts badly. In consequence of this, a current of air passes between the combustible matter and the bottom of the still, and the flame is driven into the chimney, without being turned to advantage. A violent fire is therefore required to heat the stove only to a moderate degree, in this defective construction.

Several other degrees of perfection have been successively obtained in the manufactories of Mr. Joubert: but I have judged it possible to add still more to what was known; and the following are the principles I set out from.

The whole art of distillation is reduced to the two following principles:—1. The vapours ought to be disengaged, and raised in the most economical manner: 2. And their condensation ought to be as speedy as possible.

To answer the first of these conditions, it is necessary that the boiler should present the largest possible surface to the fire, and that the heat should be every where equally applied.—2. The second condition requires that the ascent of the vapours should not be impeded, and that

that they should strike against cold bodies, which shall rapidly condense them.

The stills which I have constructed upon these principles are more broad than high; the bottom is concave, in order that the fire may be nearly at an equal distance from all the points of its surface; the sides are elevated perpendicularly in such a manner that the body exhibits the form of a portion of a cylinder; and this body is covered with a vast capital, surrounded by its refrigeratory. This capital has a groove or channel, projecting two inches at its lower part within: the sides have an inclination of sixty-five degrees; because I have ascertained that, at this degree, a drop of brandy will run along without falling again into the still. The beak of the capital is as high and as wide as the capital itself, and insensibly diminishes till it comes to the worm-pipe itself. The refrigeratory accompanies the beak or neck, and has a cock at its further end, which suffers the water to run out, while its place is supplied by other cold water, which incessantly flows in from above.

When the water of the refrigeratory begins to be warm, a cock is then opened, that it may escape in proportion as it is more plentifully supplied from above. By this means the water is kept at an equal temperature, and the vapours

vapours which strike against the sides of the head are condensed, at the same time that those which rise suffer no obstacle, as they are subjected to no contraction of space. In this construction the worm-pipe may be almost dispensed with, because the water in the worm-tub does not become perceptibly heated.

These proceedings are very economical and advantageous; for the quality of the brandy is better, and the quantity is larger.

The distillation of the wine is kept up until the product is no longer inflammable. This brandy is put into casks, when it becomes coloured by the extraction of a resinous principle contained in the wood.

The wine of our climates affords one-fifth or one-fourth of brandy, of the proof strength of commerce.

The distillation of brandy by a more moderate heat affords a more volatile fluid, called Spirit of Wine, or Alcohol. To make common spirit of wine, brandy is taken and distilled on a water bath by distillation.* This spirit of
wine

* The ardent spirit sold in London by the name of Spirit of Wine, or Lamp Spirit, is made by the rectifiers of malt and melasses spirit in London, by distillation of the residues of their compounded spirits. It is pretty constantly of the specific
gravity

wine may be purified and rectified by subsequent distillations, and taking only the first portions which come over.

Alcohol is a very inflammable and very volatile substance. It appears to be formed by the intimate union of much hydrogen and carbone, according to the analysis of Mr. Lavoisier. This same chemist obtained eighteen ounces of water by burning one pound of alcohol. If well-dephlegmated alcohol be digested upon calcined potash, and afterwards distilled, a very sweet alcohol is obtained, and a saponaceous extract, which affords alcohol, ammoniac, and an empyreumatic oil. In this experiment, the formation of volatile alkali appears to arise from the combination of the hydrogen of the alcohol with the nitrogen of the potash.

There are various methods used in the arts to judge of the degree of concentration of spirit of wine. Gunpowder is put into a spoon, and moistened with spirit of wine, which is set on fire: if the powder takes fire, the spirit is con-

gravity of 0,845 at the temperature of 60 Fahrenheit; and may, by very careful rectification, be brought nearly up to 0,820. Dry alkali deprives it of more of its water. On the subject of the strength of spirits, consult Blagden in Phil. Transf. vol. lxxxi. T.

sidered to be good ; but the contrary, if this effect does not take place. But this method is fallacious, because the effect depends on the proportion in which the spirit of wine is used : a small quantity always inflames the powder ; and a strong dose never produces this effect, because the water which remains soaks into the powder, and defends it from the combustion.

The areometer of Mr. Baumé is not to be depended on ; because, in the use of it, no account is kept of the temperature of the atmosphere, which, by changing the density of the spirit of wine, is productive of a change in the result as given by this instrument. That of Mr. Bories is more accurate, because the thermometer is adapted to it ; and it is now used in commerce.

Alcohol is the solvent of resins, and of most aromatic substances ; and consequently it forms the basis of the art of the varnisher and of the perfumer.

Spirit of wine combined with oxigene forms a liquor nearly insoluble in water, which is called Ether.

Ether has been formed with most of the known acids.

The most ancient of all is the vitriolic or sulphuric ether. To make this, a certain quantity

tity of alcohol is put into a retort, and an equal weight of concentrated sulphuric acid is gradually added. The mixture is shaken and agitated, to prevent the retort from breaking by the partial effect of the heat which arises. The retort is then placed on a heated sand bath, a receiver is adapted, and the mixture is heated to ebullition. Alcohol first passes over; soon after which, streams of fluid appear in the neck of the retort, and within the receiver, which denote the rising of the ether. Its smell is agreeable. Vapours of sulphureous acid succeed the ether; and the receiver must be taken away the moment they appear. If the distillation be continued, sulphureous ether is obtained, and the oil which is called *Ethereal Oil*, or the *sweet oil of wine*; and that which remains in the retort is a mixture of undecomposed acid, sulphur and a matter resembling bitumen.

We see that in this operation the sulphuric acid is decomposed; and that the oxygen, by combining with the hydrogen and the carbon of the alcohol, has formed three states, which we also find in the distillation of some bitumens—1. A very volatile oil or ether. 2. *Ethereal oil*. 3. Bitumen.

If the sulphuric acid be digested upon ether, it converts the whole gradually into *etherial oil*.

When the ether is mixed with sulphureous vapours, it must be rectified by a gentle heat ; a few drops of alkali being first poured in, to combine with the acid.

Sulphuric ether may be made very œconomically, by using a leaden still with a head of copper well tinned. In this way I prepare it by the quintal without any difficulty.

Mr. Cadet has proposed to pour on the residue of the retort one third part of good alcohol, and to distil it in the usual way.

Ether is very light, very volatile, and of a pleasant smell. It is so easily evaporated, that if a fine rag be steeped in this liquor, then wrapped round the ball of a thermometer, and the instrument be agitated in the air, the thermometer sinks to the freezing point*.

Ether

* Mr. Cavallo has described, in the *Philosophical Trans.* for 1781, a pleasing experiment of freezing water by means of ether. The ether is put into a vial so as not completely to fill it ; and in the neck of this vial is fitted, by grinding, a tube whose exterior end is drawn out to a capillary fineness. Whenever the bottle thus stopped is inverted, the ether is urged out of the tube in a fine stream, in consequence of the pressure exerted by the elastic ethereal vapour which occupies the superior space of the bottle. This stream is directed on the outside of a small glass tube containing water, which it speedily cools down to the freezing point ; at which instant the water becomes suddenly opaque, in consequence of the

Ether easily burns, and exhibits a blue flame. It is very sparingly soluble in water.

Ether is an excellent antispasmodic. It mitigates pains of the colic as if by enchantment, as it does likewise external pains. The celebrated Bucquet had accustomed himself so much to this drink, that he took two pints per day: a rare example of the power of habit on the constitution.

The mixture of two ounces of spirit of wine, two ounces of ether, and twelve drops of ethereal oil, forms the anodyne liquor of Hoffman.

Messrs. Navier, Woulfe, Laplanche, Bogue, and others, have described various processes for making nitric ether, which are more or less easily imitated. For my part, I take equal parts of alcohol, and nitric acid of commerce, of the strength of between thirty and thirty-five degrees. I put the whole into a tubulated retort, which I fit to a furnace, and adapt two receivers one succeeding the other. The first receiver is immersed in a vessel of water. The second is surrounded by a wet cloth: and a siphon communicates from its tubulure to a vessel of water in which it is plunged. When the

the icy crystallization. If a beaded wire be previously immersed in the water, it may afterwards be drawn out, and the ice along with it. T.

heat

heat has penetrated the mixture, much vapours are disengaged, which are condensed in striæ, on the internal surfaces of the receivers, whose external surface is kept constantly cold. The ether which I obtain is very pure and very abundant*.

When the precaution of distilling it properly is attended to, this ether becomes nearly similar to the vitriolic. Messrs. de Laffone and Cornette have observed that it was more sedative.

The distillation of the muriatic acid with alcohol produces only a mixture of these two liquors, which is called the *Dulcified Muriatic Acid*.

Before the theory of ethers, and the simple process of combining a surplus of oxygen with the muriatic acid, were known, methods were

* The ingenious author has forgotten to caution the inexperienced chemist against the danger of mixing these two liquors. The nitrous acid must be very gradually added to the spirit of wine, by small portions at a time. It is said, and with reason, to be of great importance, that the nitrous acid be added to the spirit, and not the spirit to the acid: for, in this last case, the mixture will, during the greatest part of the time of the operation of combining the fluids, consist of a large portion of acid, with a smaller portion of spirit; whereas, where the contrary method is adopted, the proportion of spirit will always be greater than that of the acid, until the last quantity of acid is added. T.

invented

invented to procure the muriatic acid; but substances were always made use of in which the muriatic acid was oxygenated. In this manner it was that the baron de Bornes proposed the concentrated muriate of zinc, mixed and distilled with alcohol; and that the marquis de Courtanvaux distilled the mixture of a pint of alcohol with two pounds and a half of the fuming muriate of tin.

The theory of the formation of ether has in our time led to simpler processes.

Mr. Pelletier introduces a mixture of eight ounces of manganese, and a pound and a half of the muriate of soda, in a large tubulated retort; twelve ounces of sulphuric acid, and eight ounces of alcohol, are afterwards added. Distillation is then proceeded on; and ten ounces of a very ethereal liquor are obtained, from which four ounces of good ether are afforded by distillation and rectification.

The very concentrated muriatic acid, distilled from manganese in the apparatus of Woulfe, affords more ether. It is even sufficient, for this purpose, to pass the oxygenated muriatic acid through good alcohol, to convert it into ether.

This muriatic ether has the greatest analogy with the sulphuric. It differs from it in two characters only—1. It emits, in burning, a
smell

smell as penetrating as that of the sulphuric acid.

2. Its taste is styptic, resembling that of alum.

From these experiments it is evident that ether is merely a combination of alcohol with the oxygen of the acids made use of. I have even obtained an ethereal liquor by repeated distillations of good alcohol from the red oxide of mercury.

The idea of Macquer, who considered ether as spirit of wine dephlegmated, or deprived of water, had little foundation: for the distillation of the spirit of wine from the most concentrated or driest alkali, never affords any thing but spirit of wine more or less dephlegmated.

Concerning Tartar.

Tartar is deposited on the sides of casks during fermentation: it forms a lining more or less thick, which is scraped off. This is called crude tartar, and is sold in Languedoc from ten to fifteen livres the quintal.

All wines do not afford the same quantity of tartar, Neumann remarked that the Hungarian wines left only a thin stratum; that the wines of France afforded more; and that the Rhenish wines afforded the purest and the greatest quantity.

Tartar

Tartar is distinguished, from its colour, into red or white: the first is afforded by red wine.

The purest tartar exhibits an imperfectly crystallized appearance: the form is the same as we have assigned to the acidulous tartrate of potash; and it is this quality which is called grained tartar (*tartre grenu*) in our refineries at Montpellier.

The taste of tartar is acid and vinous. One ounce of water, at the temperature of ten degrees above 0 of Reaumur, dissolves no more than ten grains: boiling water dissolves more, but it falls down in crystals by cooling.

Tartar is purified from an abundant extractive principle by processes which are executed at Montpellier and at Venice.

The following is the process used at Montpellier:—The tartar is dissolved in water, and suffered to crystallize by cooling. The crystals are then boiled in another vessel, with the addition of five or six pounds of the white argillaceous earth of Murviel to each quintal of the salt. After this boiling with the earth, a very white salt is obtained by evaporation, which is known by the name of Cream of Tartar, or acidulous tartrate of potash.

M. Desmaretz has informed us (*Journal de Phys.* 1771) that the process used at Venice consists

consists—1. In drying the tartar in iron boilers. 2. Pounding it, and dissolving it in hot water, which by cooling affords purer crystals. 3. Redissolving these crystals in water, and clarifying the solution by whites of eggs and ashes.

The process of Montpellier is preferable to that of Venice. The addition of the ashes introduces a foreign salt, which alters the purity of the product.

The acidulous tartrate of potash crystallizes in tetrahedral prisms cut off slantwise.

This salt is used by the dyers as a mordant : but its greatest consumption is in the north, where it is used at table as a seasoner.

Tartar appears to exist in the must, and consequently in the grape itself. This has been ascertained by the experiments of De Rouelle and the marquis de Bullion.

This salt exists in many other vegetables. It is sufficiently proved that tamarisk and sumach contain it ; and the same is true of the barberry, of balm, carduus benedictus, restharrow, water-germander, and sage.

The acidulous tartrate of potash may be decomposed by means of fire, in the way of distillation ; in which case the acid and the alkali are obtained separately. This decomposition may also be effected by the sulphuric acid.

The

The celebrated Scheele has described a process of greater accuracy for obtaining the acid of cream of tartar.

Two pounds of the crystals are dissolved in water, into which chalk is thrown by degrees, till the liquid is saturated. A precipitate is formed, which is a true tartrate of lime, is tasteless, and cracks between the teeth. This tartrate is put into a cucurbit; and nine ounces of sulphuric acid, with five ounces of water, are poured on it. After twelve hours digestion, with occasional stirring, the tartareous acid is set at liberty in the solution, and may be cleared of the sulphate of lime by means of cold water.

This tartareous acid affords crystals by evaporation; which, when exposed to the fire, become black, and leave a spongy coal behind.

Treated in a retort, they afford an acid phlegm, and some oil.

The taste of this acid is very sharp.

It combines with alkalis, with lime, with barytes, alumine, magnesia, &c.

The combination of potash with this acid forms cream of tartar, when the acid is in excess; which is capable of entering into combinations, and forming triple salts. Such is the salt of Seignette, or tartrate of soda, which crystallizes in tetrahedral rhomboidal prisms.

The

The acidulous tartrate of potash is very sparingly soluble in water. Boiling water dissolves only one twenty-eighth part. The addition of borax has been proposed to facilitate the solution; as likewise sugar, which is less efficacious than borax, but makes a very agreeable and purgative lemonade with this salt.

ARTICLE II.

Concerning the Acid Fermentation.

The mucilaginous principle is more especially the substance on which the acid fermentation depends; and when it has been destroyed, in old and generous wines, they are no longer capable of alteration, without the addition of a gummy matter, as I find from my own experiments. It is not true, therefore, to say that all substances which have passed through the vinous fermentation, are capable of passing to the state of vinegar; since this change depends on the mucilage, which may not in all cases be present.

There are, therefore, three causes necessary to produce the acid fermentation in spirituous liquors.

1. The

1. The existence of mucilaginous matter, or mucilage.
2. A degree of heat between eighteen and twenty-five degrees of Reaumur.
3. The presence of oxygenous gas.

The process indicated by Boerhaave for making vinegar, is still the most frequently used. It consists in fixing two casks in a warm room or place. Two false bottoms of basket-work are fixed at a certain distance from the bottom, upon which the refuse of grapes and vine twigs are placed. One of these tuns is filled with wine, and the other only half filled. The fermentation begins in this last; and, when it is in full action, it is checked by filling the cask up with wine out of the other. The fermentation then takes place in the last-mentioned cask, that remained half filled; and this is checked in the same manner by pouring back the same quantity of liquid out of the other; and in this way the process is continued till the vinegar is made, which is usually in about fifteen days.

When the fermentation develops itself, the liquid becomes heated and turbid; a great number of filaments are seen in it; it emits a lively smell; and much air is absorbed, according to the observation of the abbé Rosier.

A large quantity of lees is formed, which subsides

sides when the vinegar becomes clear. This lees is very analogous to the fibrous matter.

Vinegar is purified by distillation. The first portions which pass over are weak; but soon afterwards the acetous acid rises, and is stronger the later it comes over in the distillation. This fluid is called Distilled Vinegar; and is thus cleared of its colouring principle, and the lees, which is always more or less abundant.

Vinegar may likewise be concentrated by exposing it to the frost. The superabundant water freezes, and leaves the acid more condensed.

The presence of spirit of wine, mucilage, and air, are necessary to form vinegar. Scheele has made it by decomposing the nitric acid upon sugar and mucilage. I communicated to the Academy at Paris (vol. 1786) an observation of some curiosity respecting the formation of vinegar. Distilled water, impregnated with vinous gas, affords vinegar: at the end of some months, a deposition is made of a substance in flocks, which is analogous to the fibrous matter of vegetables. When the water contains sulphate of lime, an execrable hepatic odour is developed, a deposition of sulphur is afforded, and all this is owing only to the decomposition of this sulphuric acid.

As

As in the above experiments I had placed the water above the vinous fluid in fermentation, to impregnate it with the carbonic acid, the alcohol which evaporates with the acid carried the mucilage with it; and the effects, I observed, are referable to this substance.

The acetous acid is capable of combining with a stronger dose of oxigene; and then forms radical vinegar, or the acetic acid.

To form the acetic acid, the metallic oxides are dissolved in the acetous acid; the salt which is obtained being then exposed to distillation, affords the oxygenated acid. It has a very lively smell, is caustic, and its action upon bodies is very different from that of the acetous acid.

This acetic acid has the advantage of forming ether with alcohol. For this purpose, equal parts of the acid and alcohol are to be distilled together. The product of the distillation is to be again added to the residue in the retort; and a small quantity of the water of Rabel is likewise to be added. The whole becomes converted into ether.

The combination of the acetous acid with potash forms the acetite of potash.

To make this salt, pure potash is saturated with distilled vinegar, the liquor filtered, and evaporated to dryness in a glass vessel over a
very

very gentle fire. The acetite of potash has a penetrating acid taste; is decomposed by distillation; and affords an acid phlegm, an empyreumatic oil, ammoniac, and a large quantity of very odorant gas, formed of carbonic acid and hydrogen. The coal contains much fixed alkali in a disengaged state. This salt is very soluble in water, and deliquesces in the air.

The sulphuric acid poured upon it, decomposes it; and the products which come over are sulphuric acid and acetic acid.

The acetous acid likewise combines with soda; and this combination is improperly called Crystallizable Terra Foliate. The acetite of soda crystallizes in striated prisms, and does not attract the humidity of the air. When these salts are distilled, they leave a residue, which forms an excellent and very active pyrophorus.

The acetous acid likewise combines with ammoniac. The acetite which is produced is called the Spirit of Mindererus. This salt cannot be evaporated without the loss of a considerable part, on account of its volatility: but, by a long evaporation, it affords needle-formed crystals, of a hot and penetrating taste, and attracting moisture from the air. Lime, fixed alkalis, mere heat or fire, and the acids, decompose this salt.

The

The sulphate of potash, sprinkled with the acetic acid, forms the salt of vinegar.

ARTICLE III.

Concerning the Putrid Fermentation.

In order that vegetables may undergo the two fermentations we have treated of, it is necessary that the juices should be extracted, and presented in a considerable volume. A due degree of heat, together with other circumstances artificially brought together, are likewise necessary; for a grape, left on the stalk, produces neither ardent spirit nor vinegar, but rots. It is this new kind of alteration we shall at present proceed to treat of.

This fermentation is the most natural termination of the vegetable. It is indeed the only end to which the natural course of things is directed; since it is by this means that the exhausted surface of the globe is repaired. The two other fermentations are the mere effects of art, and form no part of the great plan of nature.

The life of the greatest part of vegetables lasts but a few months; but the seeds they deposit

assure their re-production. There are other more robust vegetables which support the cold of winter, and only cast their leaves at that period. The annual vegetables, and vivacious plants, are altered by the combined action of the causes we have mentioned; and the result, according to the degree of decomposition, is either manure, vegetable earth, or ochre.

The conditions of the vegetable fermentation are the following :

1. It is necessary that the organization be impregnated with water. Dried vegetables are preserved without putrefying; and, if they be moistened, their subsequent alteration is prodigiously accelerated. In this manner it is that plants heaped together become heated, blacken, and take fire, if not sufficiently dried. Fires of this kind are not rare, and the theory is not difficult to be explained. Wetted ropes, moist hay heaped together, and in a word every vegetable substance, putrefies or rots with greater facility, the more perfectly its texture is impregnated with water.

2. The contact of air is the second necessary cause in the putrefaction of vegetables. It is reported, in the *Ephemerides of the Curious in Natural Phenomena*, for 1787, that ripe cherries were preserved for forty years, by inclosing them

them in a vessel well luted, and placed at the bottom of a well.

3. A certain degree of heat is likewise necessary. The heat between five and ten degrees is sufficient to cause decomposition. A greater heat dissipates the humidity, dries the vegetable, and preserves it from putrefaction. Too little heat retards or suspends it.

4. It is likewise necessary, for the due effect of this decomposition, that the vegetables should be heaped together, and their juices abundant. A greater quantity of air is then combined with the vegetable: because the juices and the surfaces are then more considerable; and consequently a greater degree of heat is produced, which accelerates the decomposition.

When vegetables are heaped together, and their texture is softened by the humidity with which they are impregnated, together with their own juices, the phenomena of decomposition are the following:—The colour of the vegetable is changed; the green leaves become yellow, the texture becomes lax, and the parts less coherent; the colour of the vegetable itself changes to black or brown; the mass rises, and perceptibly swells up; the heat becomes more intense, and is perceived on approaching the heap; and the fumes which arise have already a

smell, which sometimes is not disagreeable; at the same time bubbles arise, and break at the surface of the liquid, when the vegetables are reduced to a magma. This gas is a mixture of nitrogene, hydrogene, and carbonic acid. At this epocha, likewise, an ammoniacal gas is emitted, which is formed in these circumstances: and, in proportion as these appearances diminish, the strong and offensive odour is succeeded by another which is fainter and milder, and the mass becomes dry. The internal part still exhibits the vegetable structure, when the stem is solid, and the fibrous matter has been the predominating principle; and it then constitutes manure or soil. Hence it arises that the herbaceous plants of a loose texture, and abounding in juices, are not capable of forming manure by their decomposition, but are reduced into a brown mass of little consistence, in which neither fibre nor texture are observed; and this is what, for the most part, forms vegetable mould.

Vegetable mould usually constitutes the first covering or stratum of our globe; and in such cases wherein it is discovered at a depth in the earth, there is no doubt but it has been buried by some revolution.

When a vegetable is converted into earth by
this

this tumultuous fermentation, it still retains the remains of the vegetable, mixed and confounded with the other solid earths and metallic products; and by distillation it affords oil, nitrogenous gas, and often hydrogenous. It may therefore be considered as an intermediate substance, between crude and organic bodies, which participates of the inertia of the one, and the activity of the other; and which in this state is still subject to an insensible fermentation, that changes its nature still more, and deprives it of all its organic contents. These remains of vegetables still contained in vegetable earth, serve as food for other plants that may grow in it. The insensible progress of fermentation, and the suction of vegetables, impoverish the vegetable earth, deprive it of all its organic matter, and there remain only the earths and metallic residue which form the stiff poor soils, and ochres when the ferruginous principle is very abundant.

As this muddy earth is a mixture of all the primitive earths, and some of the metals which are the product of vegetation, as well as the oils, the salts, and other products we meet with in it; we may consider it as the residue of vegetable decomposition, as the great agent and means by which nature repairs the continual

losses

losses the mineral kingdom undergoes. In this mixture of all the principles the materials of all compounds exist; and these materials are so much the more disposed to enter into combinations, as they are in a more divided and disengaged state. It is in these earths that we find diamonds, quartz-crystals, spars, gypsum, &c. It is in this matrix that the bog ores, or ochreous ores of iron, are formed; and it appears that nature has reserved the impoverished residue of vegetables for the reproduction or reparation of the earthy and metallic substances of the globe, while the organic remains are made to serve as nourishment for the growth of other succeeding vegetables.

PART VI.

CONCERNING ANIMAL SUBSTANCES.

INTRODUCTION.

THE abuse which, at the commencement of this century, was made of the application of chemistry to medicine, occasioned, a short time afterwards, that all the relations between this science and the art of healing were mistaken and rejected. It would no doubt have been more prudent, as well as more useful, to have connected these mistaken applications : but chemistry was not perhaps at that time in a sufficiently advanced state, to be advantageously applied to the phenomena of living bodies ; and, even at this day, we see that, though the physiology of the human body is enriched with various interesting facts, there is still much to be done before they will be sufficiently numerous to exhibit a satisfactory mass of doctrine.

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The imperfect success of chemistry in that branch of the Science which has the study of man for its object, arises from the very nature of the subject itself. Some chemists, by considering the human body as a lifeless and passive substance, have supposed the humours to undergo the same changes as they would have been subject to out of the body; others, from a very superficial knowledge of the constitution of these humours, have pretended to explain all the phenomena of the animal œconomy. All have mistaken or overlooked that principle of life which incessantly acts upon the solids and fluids; modifies, without ceasing, the impression of external objects; impedes the degenerations which depend on the constitution itself; and presents to us phenomena which chemistry never could have known or predicted by attending to the invariable laws observed in inanimate bodies.

None of the bodies of the mineral kingdom are governed by an internal force. They are all subjected to the direct action of foreign substances, without any modification from any vital principle; and the air, water, and fire, produce in them effects which are necessary, constant, and subject to calculation: whence it happens that we are able to determine, modify, and vary the action of these various agents at pleasure. It
is

is not the same with living bodies : they are all indeed subject to the influence of external bodies ; but the effect of these is modified by the reaction of the vital principle, and is varied according to the disposition of that principle. The chemist cannot therefore determine these effects *à priori*, and in a general way. He must search for his results rather in the living body itself than in the operations of his laboratory ; and can have no assistance from his analysis but in ascertaining the nature of their component parts. But their action, effects, or transpositions, can only be known by a serious study of the functions of the living body. Chemistry can perform every thing in the mineral kingdom, because every thing depends on the laws of the affinities. But, in the kingdoms of organized beings, this science is subordinate to the laws of the œconomy of living bodies ; and its results can only be affirmed to be true, when they are confirmed by observation.

The more the functions of the individual are independent of organization, the less is the empire of chemistry over them, because the effects are modified in a thousand ways ; and it is this which renders the application of chemical principles to the phenomena of the human body so very difficult : for the organization is not only
very

very complicated, but the effects are continually varied by the powerful influence of the mind.

There is not however any function in the animal œconomy, upon which the science of chemistry cannot throw some light. If we consider them in the healthy state, we shall perceive that every organ produces some change in the humours it receives ; and, though the chemist may indeed be ignorant of the manner in which such changes are produced, it is by his art alone that the difference between the original fluid, and that which has been elaborated, can be ascertained. Besides which, the functions of the various organs are exercised upon external objects, and these objects come under the consideration of chemistry. We are at present, for example, acquainted with the nature of the air which serves for respiration, its effects on the lungs, and its influence on the animal œconomy. We are even now able to determine whether any air be good or bad, and know how to correct that which is vitiated, &c. We likewise possess some accurate ideas of the nutritive principle of certain substances ; and chemistry teaches us how to dispose of the respective aliments, and adapt them to the various circumstances. The analysis of waters is sufficiently
perfect

perfect to admit of our distinguishing the properties of that fluid relative to health, and to select the best for our own use: so that, while the principle of life presides over and governs all the internal operations of the human body, by a mechanism which is very imperfectly known to us, we see nevertheless that all the functions receive an impression more or less direct from external objects; that all the materials used for the support of the machine are supplied from without; that the principle of life which collects and disposes of these materials, after laws unknown to us, is capable neither of choosing nor rejecting them; and that the functions would be very speedily altered, if chemistry, founded on observation, were not careful to remove the noxious, and select such bodies as are of advantage to the system. Chemistry therefore can do nothing in the arrangement of the materials, but possesses unlimited power in their selection and preparation.

When the organization is deranged, this defect of order can arise only from external or internal causes. In the first case, the analysis of the air, the water, and the foods, will afford accurate notions sufficient to re-establish the functions. In the second, the chemical examination of the humours may afford information

tion sufficient to direct the physician in pointing out the most suitable remedy. Sometimes the humours are decomposed in the body, as *in vitro*. We observe all the phenomena of a degeneration and complete disunion of the principles which compose the blood, in the scurvy, cachexy, malignant fevers, &c. It seems as if, in such cases, the vital principle abandoned the government, and left the solids and fluids to the destructive action of external agents; in consequence of which they become decomposed in the same manner as they usually do when separated from the body.

When the principle of animality is once extinguished, the same causes which maintained the functions, and whose effects were modified by that principle of life, now act with their whole energy on the body, and decompose it. Chemistry has discovered methods of extracting from these dead bodies a variety of substances of use in the arts and in pharmacy.

Chemistry is therefore applicable to the animal œconomy in the state of health and in the state of sickness.

The chemical art has marked the limits between vegetable and animal substances. These last afford ammoniac by putrefaction, while the fermentation of the former develops ardent spirit.

spirit. The latter leave a coal which burns easily; while the former become converted into a coal almost incombustible. Animal matters contain much nitrogene, which may be disengaged by means of nitric acid. The interesting Memoirs of Mess. Berthollet and De Fourcroy on animal substances, may be consulted to great advantage.

C H A P. I.

Concerning Digestion.

THAT humour which is known by the name of the Gastric Juice, is separated by glands placed between the membranes which line the stomach; and from these it is emitted into the stomach itself.

In order to obtain the gastric juice in a state of purity, the animals intended to furnish it are kept fasting for two days, after which the stomach is extracted. In this manner Spallanzani obtained thirty-seven ounces of this juice out of the two first stomachs of a sheep. The same naturalist caused animals to swallow thin tubes of metal, pierced with several holes, into which he

he had put small sponges, very clean and dry. He caused crows to swallow eight at a time, which were vomited up at the end of three hours and a half. The juice which he obtained was yellow, transparent, salt, bitter, and leaving very little sediment, when the bird was fasting. The gastric juice may likewise be procured by the vomiting which is excited by irritation during fasting. M. Scopoli has observed that the most fluid part only is thrown up by irritation; and that the thicker part does not quit the stomach but by the assistance of an emetic. M. Goffe, who had long accustomed himself to swallow the air, which answered the purpose of an emetic with him, has availed himself of this habit to make some experiments with the gastric juice. He suspends his respiration, receives air into his mouth, and pushes it towards the pharinx with his tongue. This air, rarefied in his stomach, produces a convulsive motion, which clears it of its contents. Spallanzani has observed that eagles spontaneously emit a considerable quantity of gastric juice, when fasting in the morning.

We are indebted to Reaumur and the abbé Spallanzani for very interesting experiments respecting the virtue and effects of the gastric juice in digestion. They caused animals to swallow
tubes

tubes of metal, perforated in various places, and filled with aliments, to examine their effects. The philosopher of Pavia used purses of thread, and bags of linen and of woollen. He himself swallowed small purses filled with flesh boiled or raw, with bread masticated, and also in its original state, &c. and likewise small cylinders of wood, five lines in length and three in diameter, pierced with holes, and covered with cloth.

M. Goffe, availing himself of the facility with which he was able to vomit by means of the air, has taken all kinds of food, and examined the changes they had undergone, by returning them after intervals more or less remote from the time of deglutition.

From these various experiments it follows—

1. That the gastric juice reduces the aliments into an uniform magma, even out of the body, and *in vitro*; and that it acts in the same manner on the stomach after death: which proves that its effect is chemical, and almost independent of vitality.
 2. That the gastric juice effects the solution of the aliments included in tubes of metal, and consequently defended from any trituration.
 3. That though there is no trituration in membranous stomachs, this action powerfully assists the effect of the digestive juices in animals whose stomach is muscular,
- such

such as ducks, geese, pigeons, &c. Some of these animals bred up with sufficient care that they might not swallow stones, have nevertheless broken spheres and tubes of metal, blunted lancets, and rounded pieces of glass, which were introduced into their stomachs. M. Spallanzani has ascertained that flesh included in spheres sufficiently strong to resist the muscular action, was completely digested. 4. That the gastric juice acts by its solvent power, and not as a ferment : because the ordinary and natural digestion is attended with no disengagement of air, nor inflation, nor heat, nor in a word with any of the phenomena of fermentation.

M. Scopoli observes very well that nothing positive or certain can be asserted respecting the nature of the gastric juice. It is sometimes acid and sometimes insipid. M. Brugnatelli has found in the gastric juice of carnivorous birds, and some others, a disengaged acid, a resin, and an animal substance, united with a small quantity of common salt. The gastric juice of ruminating animals contains ammoniac, an extractive animal substance, and common salt. In our time the phosphoric salts have been found disengaged in the gastric juice.

It appears, from the observations of Messrs. Spallanzani and Goffe, that the nature of the
gastric

gastric juice varies according to that of the aliments. This juice is constantly acid when the diet is vegetable. The abbé Spallanzani affirms, contrary to Messrs. Brugnatelli and Carminati, that birds of prey have never afforded him an acid juice; and he affirms the same of serpents, frogs, fishes, &c.

In order to shew clearly that there is a great difference between the gastric juices of various animals, it is sufficient to observe that the gastric juice of the kite, the falcon, &c. does not dissolve bread, though it digests flesh meat; and that the gastric juice of the turkey, the duck, &c. has no action upon flesh, but converts the hardest grain into a pulp.

Messrs. Jurine, Toggia, and Carminati have made the most successful applications of the gastric juice in the treatment of wounds.

C H A P. II.

Concerning Milk.

OF all the animal humours, milk is beyond contradiction the least animalized. It appears to partake of the nature of chyle; it preserves the qualities and character of the ali-
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ments; and for this reason we are induced to place it at the head of the humours of animal bodies.

Milk is separated in organs called breasts or udders; and though the class of animals with breasts exhibits the greatest analogy in the internal construction of these organs, yet the milk varies in the several species. In the human species it is more saccharine; in the cow, milder or softer: the milk of the goat, and of the ass, are slightly astringent: and it is for this reason that they are ordered to be taken in disorders which have weakened and exhausted the human frame*.

Milk is the first food of young animals. Their

* It seems most probable that the pre-eminence still given to the milk of the ass, arises from no better reason than the loud and sonorous voice of the animal, which, by a kind of reasoning very common among the ancient physicians, has led to a conclusion that the milk of such a creature must be good for the lungs. The root satyrion, the milk of the goat, and many other substances, formerly stood high in medical estimation, for reasons equally obvious and equally superficial. It must not however be denied but that, when the possessor of an exhausted constitution becomes so far obedient to advice as regularly to take asses milk, and attend to other circumstances of regimen, he may find himself benefited; and the asses milk, merely as milk, substituted instead of some less friendly beverage or food, may be entitled to a share in the general effect. T.

weak

weak and feeble stomachs are incapable of digesting and assimilating aliments afforded by the earth ; and nature has accordingly provided them a food more animalized, and consequently more analogous to their structure, until their increased strength permits them to use a coarser food.

Hunter has observed that all the animals which disgorge to feed their young, have glands in the stomach, which are formed during the incubation, and afterwards gradually obliterated.

Milk is in general of an opaque white colour, and saccharine taste.

By attending to the various alterations it undergoes when left to itself, or when decomposed by chemical agents, we may arrive at a perfect knowledge of its nature.

Milk exposed to the air is decomposed in a longer or shorter time, according to the degree of heat of the atmosphere. But if the temperature of the atmosphere be hot, and the milk in large quantity, it may pass to the spirituous fermentation. Marco Polo, the Venetian, who wrote in the thirteenth century, affirms that the Tartars drink mares milk, so well prepared that it might be taken for white wine. Claude Strahlenberg reports that the Tartars extract a vinous spirit from milk, which

they call Arki (*Description de l'Empire de Russie*). John George Gmelin, in his *Voyage to Siberia*, affirms that the milk is suffered to become sour, and is afterwards distilled.

M. Nicolas Oseretzkowsky, of St. Petersburg, has proved—1. That milk deprived of its cream cannot produce ardent spirit, either with a ferment or without. 2. That milk agitated in a close vessel affords ardent spirit. 3. That fermented milk loses its spirituous principle by heat, and passes to the state of vinegar.—*Journal de Phys.* 1779.

Milk becomes sour in the summer, and in three or four days the acid has acquired all its strength. If the whey be then filtered, and evaporated to half, cheese is deposited. If it be again filtered, and a small quantity of the tartareous acid be added, a quantity of small crystals of tartar are seen to be formed in the course of an hour afterwards, which according to Scheele can (not) arise only from the small quantity of muriate potash (in milk, but from an essential salt*) which milk always contains.

To separate the various principles contained in sour whey, the following process may be

* The words in the parentheses are added, to render the text conformable to Scheele's Essay. T.

used,

used, which was pointed out by the celebrated Scheele.

Evaporate the four milk to one eighth. All the acid separates, and remains on the filtre. Pour lime water on the residue ; an earth is precipitated, and the lime combines with the acid. The lime may be displaced by the oxalic acid, which forms with it an insoluble oxalite, which falls down, and the acid of milk remains disengaged. The fluid is then to be evaporated to the consistence of honey, and upon this very pure alcohol is to be poured. The sugar of milk, and all the other principles, are insoluble, except the acid. The mass being then filtered, the acid of milk may be separated from its solvent by distillation. This is the acid known by the name of Lactic Acid. It possesses the following characters.

1. When saturated with pot-ash, it affords a deliquescent salt, soluble in alcohol.

2. With soda, a salt not crystallizable, and soluble in alcohol.

3. With ammoniac, a deliquescent salt, which suffers most of its alkali to escape before the heat has destroyed the acid.

4. Barytes, lime, and alumine, form with it salts which are deliquescent.

5. Mag-

5. Magnesia affords small crystals, which are resolved into a liquor.

6. Bismuth, cobalt, antimony, tin, mercury, silver, and gold, are not attacked by it either hot or cold.

7. It dissolves iron and zinc, and produces hydrogenous gas. The solution of iron is brown, and does not afford crystals: that of zinc crystallizes.

8. With copper it assumes a blue colour, which changes to green, and afterwards to an obscure brown, without crystallizing.

9. When kept in digestion upon lead for several days, it dissolves it. The solution does not afford crystals. A light sediment of a white colour is formed, which Scheele considers as a sulphate of lead.

Whey not four contains a saline substance, known by the name of Sugar of Milk. Messrs. Valgamo and Lichtenstein have described the process used to obtain this saline substance. The milk is deprived of its cream in the usual manner, and of its curd by rennet. It is then concentrated by evaporation till it has acquired the consistence of honey, after which it is put into moulds, and dried in the sun. This is called Sugar of Milk in Cakes (*sucre de lait en tablettes*). These cakes are dissolved in water, clarified

clarified with white of egg, evaporated to the consistence of syrup, and set to crystallize in a cool place. It affords white crystals in rhomboidal parallelopipedons.

Sugar of milk has a slightly saccharine taste, insipid, and as it were earthy. It is soluble in three or four pints* of hot water. M. Rouelle obtained from twenty-four, to thirty grains of ashes from one pound of this salt burned. Three-fourths consisted of muriate of potash, and the rest was carbonate of potash.

Sugar of milk exhibits the same appearances as sugar, either by distillation, or on the fire. This salt †, treated with the nitric acid, afforded me three gros of oxalic acid in the month of July 1787 (*Mémoire présenté à la Société Royale des Sciences de Montpellier*). Scheele observed the same fact nearly at the same time. I obtained it in beautiful crystals; Scheele, in the form of a white powder ‡.

If

* By an oversight for *parts*. T.

† The quantity of salt used is not put down. Scheele obtained five drachms of acid of sugar in long crystals, by distilling nitrous acid from twelve ounces of sugar of milk, and seven drachms and a half of the peculiar acid of sugar of milk in a white powder. The memoir of Scheele is dated 1780. T.

‡ I do not see by what oversight it is that our ingenious author

If fix spoonfuls of good alcohol be mixed with three pints of milk, and the mixture be exposed to heat in close vessels, with the attention to give, from time to time, a slight vent to the gas of the fermentation; the milk

author seems to confuse the two salts together, which are afforded by treating the sugar of milk with nitrous acid. One, as observed in the preceding note, is the oxalic or saccharine acid, and the other the acid of sugar of milk. The properties of this last (Scheele's *Essays*, London, 1786) are the following:

1. It is combustible like oil in a red-hot crucible, without leaving any mark of ashes behind.
2. Sixty parts of boiling water, or eighty of cold water, are required to dissolve it.
3. Its taste is sourish, it reddens tincture of litmus, and effervesces with chalk.
4. By destructive distillation it melts, grows black, froths very much; a brown salt, smelling like a mixture of flowers of benzoin and acid of amber, sublimes; a brown liquid, without any appearance of oil, comes over into the receiver, and is found to contain some of the same kind of salt as was sublimed. The sublimed salt is acid, easily soluble in ardent spirit, but more difficultly in water, and burns in the fire with a flame.
5. With all the soluble earths it forms salts insoluble in water.
6. With vegetable alkali it forms a perfectly neutral crystallizable salt, soluble in eight times its weight of boiling water, and separable for the most part by cooling.
7. With mineral alkali it forms a salt which requires only five parts of boiling water for its solution.
8. With volatile alkali it forms a salt which, after being gently dried, has a sourish taste.
9. It does not perceptibly act on the metals; but forms, with their calces, salts of very difficult solubility, which therefore fall down.

T.

is found, in the course of a month, to be changed into good acetous acid, according to Scheele.

If a bottle be filled with fresh milk, and inverted beneath the surface of milk in an open vessel, and this be subjected to a degree of heat a little exceeding that of summer, at the end of twenty-four hours the milk is found to be coagulated; the gas which is developed displaces the milk: a proof, according to Scheele, that the vinous fermentation has taken place.

To decompose milk, and separate its various constituent parts, rennet, or the milk turned sour in the stomach of calves, is commonly made use of. For this purpose the milk is warmed, and twelve or fifteen grains of rennet is added to each pint. Gallium, the flowers of thistle or artichokes, and the internal membrane of the stomach of birds dried, and reduced to powder, &c. are among the substances which may be used to turn milk. The whey obtained in this manner is turbid; but may be clarified by boiling it with white of egg, and subsequent filtration.

On the mountain of Larzac I have seen the dairy woman plunge her arms up to the elbows in the milk, and change their place from time

to

to time. This was done with a view to hasten the separation of the principles; and it is probable that the heat, and perhaps certain emanations from the arm itself, might favour that effect.

The solid mass which separates from whey, contains two other substances very interesting to be known; namely, cheese and butter.

If any vegetable or mineral acid be put into milk, a coagulation follows, as is well known. The only difference is, that the mineral acid affords less cheese or curd than the vegetable; and the various substances used to coagulate milk, may perhaps act merely by virtue of the acid they contain. Olaus Borrichius obtained an acid from curdled milk at a degree of heat incapable of decomposing it. The coagulum which is afforded in all these cases, contains a substance of the nature of gluten, which forms the cheese; and another substance of the nature of oils, which forms the butter. When cheese is prepared for the table, the butter is not separated, because it renders it milder and more agreeable.

The caustic alkalis dissolve cheese by the assistance of heat. But it is not held in solution by an alkali in milk.

If one part of cheese newly separated, and
not

not dried, be mixed with eight parts of water slightly acidulated by a mineral acid, and the mixture be boiled, the cheese will be dissolved, though it would not have been sensibly acted on by a vegetable acid. This is the cause why the vegetable acids separate a much greater quantity of curd from the same quantity of milk than the mineral acids do.

The cause why salts, gums, sugar, &c. coagulate milk, may be deduced from the greater affinity of the water with these bodies than with the cheese.

The earth of cheese is a phosphate of lime, according to Scheele.

No substance has a stronger resemblance to cheese than the white of egg boiled. White of egg is dissolved in diluted acid, and also in caustic alkali, and in lime-water, and is precipitated from them by acids.

Scheele thinks that the coagulation of white of egg, lymph, and cheese, is owing to the combination of caloric; and he proves his opinion as follows:—Mix one part of white of egg with four parts of water; pour in a small quantity of pure alkali; add as much muriatic acid as is necessary to saturate it, and the white of egg will coagulate. In this experiment there is a change of principles. The heat of the alkali

kali combines with the white of egg, and the alkali with the muriatic acid*.

Ammoniac dissolves cheefe more effectually than fixed alkalis. If a few drops be poured into coagulated milk, it quickly causes the coagulum to disappear.

Concentrated acids likewise dissolve it. Nitric acid disengages nitrogene.

The curd dried, and placed in a proper situation to undergo a commencement of the putrid fermentation, acquires consistence, taste, and colour. In this state it is used at table by the name of Cheefe.

At Roquefort, where I have attended the manipulations of the excellent cheefe which is made there, care is taken to press the curd well, in order to expel the whey, and to dry it as accurately as possible. After this it is taken

* The reasoning of Scheele is more fully this:—Heat coagulates white of egg, without diminishing its weight: whence he concludes coagulated white of egg to be a combination of heat with white of egg. Acids expel heat from caustic alkalis when they combine with them, but not from mild alkalis. A very dilute alkali is used in this experiment, that the temperature may not be raised, and nevertheless the effect takes place; but it does not when a mild alkali is used. Whence he concludes that the heat of the caustic alkali, instead of being employed to raise the temperature, has entered into combination with the white of egg, and coagulated it. T.
into

into caves, where the temperature is two or three degrees above 0. The fermentation is developed by a small quantity of salt. The putrefaction is suspended by scraping the surface from time to time; and the fermentation thus governed by art, and kept under by the coolness of the caves, produces a slow effect upon all the cheese, and successively develops the red and blue colours, of which I have given the etiology in a Memoir on the Fabrication of Cheese at Roquefort, presented to the Royal Society of Agriculture, and printed in the fourth volume of *Annales Chimiques*.*.

Butter is the third principle contained in milk. It is separated from the scum and the caseous matter by rapid agitation. The substance called cream is a mixture of cheese and butter which floats on the top of the milk. Violent agitation converts this into froth; in which state it is called *whipped cream*.

Butter has a soft consistence, is of a yellow golden colour, more or less deep, of a mild agreeable flavour, melts easily, and becomes solid again by mere cooling.

Butter is easily changed, and becomes rancid

* It is in the fourth volume of the *Annales de Chimie* that the author has inserted an extract from his excellent Memoir on this subject. T.

like oils. The acid which is developed may be carried off by water, or by spirit of wine, which dissolve it. Fixed alkali dissolves butter, and forms a soap little known.

Distillation affords a coloured concrete oil from butter, and a strong pungent acid. This oil, by repeated distillation, becomes altered, and resembles volatile oils.

Milk is therefore a mixture of oil, lymph, serum, and salt. This mixture is weakly united, and the union between the principles is easily destroyed. Milk is said to be *turned* when the disunion of its principles is effected by mere repose: but when this separation is made by reagents, it is said to be *curdled** or coagulated.

C H A P. III,

Concerning the Blood.

BLOOD is that red humour which circulates in the human body by means of the arteries and veins, and supports life by supply-

* *Lait tourné* and *lait caillé*. This distinction scarcely obtains in the English language. T.

ing all the organs with the peculiar juices they demand. It is this humour which receives the product of digestion from the stomach, which it elaborates and animalizes. This humour is with reason considered as the focus of life. The difference of tempèraments with regard to the passions, has been attributed to it by all the philosophers who have treated this subject. It is in vain that physicians have changed their system; for the opinions of the people have been less versatile, and they have continued to attribute all the shades of temperament to the modifications of the blood. It is likewise to the alterations of this humour that physicians have for a long time ascribed the cause of almost every malady. It is more especially entitled to the attention of the chemist.

The blood varies in the same individual, not only with regard to the state of health, but likewise at the same instant. The blood which circulates through the veins has not the same intensity of colour, nor the same consistence, as that of the arteries; that which flows through the organs of the breast differs from that which passes languidly through the viscera of the lower belly.

The blood differs also—1. According to the age. In infancy it is paler and less consistent.

2. Ac-

2. According to the temperament. Sanguine persons have the blood of a vermillion red ; in the phlegmatic it is paler ; and in the choleric it is more yellow.

The temperature of the blood is not the same in the several species of animals. Some have the blood hotter, and some colder, than the medium in which they live. Animals with lungs have the blood redder and hotter than those which are without that organ ; and the colour and heat are in proportion to the extent and perfection of the lungs, as M. Buffon and Broussonet have observed.

The blood putrefies by a gentle heat. If it be distilled on the water bath, it affords phlegm of a faint smell, which easily putrefies. Blood dried by a proper heat effervesces with acids ; if exposed to the air, it attracts humidity ; and at the end of several months a saline efflorescence is formed, which Rouelle has ascertained to be soda. If the distillation of blood be carried farther, the product is acid, oil, carbonate of ammoniac, &c. A spongy coal remains in the retort, of very difficult incineration, in which are found sea salt, carbonate of soda, iron, and phosphate of lime.

Alcohol and the acids coagulate the blood : alkalis render it more fluid.

But

But if the blood received in a shallow basin be observed, the following alterations are seen : —It first becomes divided into two very distinct substances, the one liquid, slightly greenish, and called lymph, or serum ; and the other reddish and solid, called the fibrous part of the blood. It is this separation of the blood which has caused the existence of polypi in the larger vessels to be credited, because concretions have been found in those vessels after death. We will separately examine these two substances.

Serum has a yellow colour, inclining to green. Its taste is slightly saline. It contains a disengaged alkali, turns syrup of violets green, and hardens in a moderate heat, which is the character of the lymph. Serum distilled on a water-bath affords an insipid phlegm, neither acid nor alkaline, but very readily putrefying. When this phlegm has passed over, the residue is transparent like horn, no longer soluble in water, and affording by distillation an alkaline phlegm, carbonate of ammoniac, and a fetid blackish oil more or less thick ; the remaining coal in the retort is very voluminous, and very difficult to incinerate ; the ashes afford muriate of soda and phosphate of lime.

Serum easily putrefies, and then affords much carbonate of ammoniac.

Serum poured into boiling water coagulates; but it contains a part which is soluble in water, to which it communicates a milky colour, and all the properties of milk, according to Bucquet.

Alkalis render the serum more fluid, but acids coagulate it. By filtering and evaporating the fluid, a neutral salt is obtained, consisting of the acid employed, and soda. It appears therefore that the lymph is kept in the liquid state by the predominating alkali.

The thickened serum affords mephitic by the nitric acid, assisted by a slight heat; if the fire be increased, nitrous gas is disengaged: the residue affords the oxalic acid, and a portion of malic acid.

Serum is coagulated by alcohol; but the coagulum is soluble in water, and in this it differs much from the coagulum formed by acids: this difference depends on the circumstance that the alcohol seizes the water which diluted the serum; whereas the acid seizes the alkali which dissolved it.

The clot or fibrous part of the blood likewise contains much lymph; but this may be disengaged by washing. The water at the same time carries off the colouring matter, which contains much iron: and this coagulated part,

part, when well washed; forms a fibrous white substance void of smell; which, distilled on the water-bath, affords an intipid phlegm, easily susceptible of putrefaction. The residue becomes very dry, even by a gentle heat; when suddenly exposed to a considerable heat, it shrinks up like parchment; but when distilled in a retort it affords an alkaline phlegm, carbonate of ammoniac, oil, &c. The coal, which is less voluminous and lighter than that of lymph, affords the phosphate of lime by incineration.

The fibrous part putrefies with considerable quickness, and affords much ammoniac.

The alkalis do not dissolve it, but acids combine with it. The nitric acid disengages much nitroge, and afterwards dissolves it with effervescence, and disengagement of nitrous gas. The residue affords oxalic acid, and a small quantity of the malic acid.

This fibrous substance is of the nature of the muscular fibre, which caused Bordeu to call the blood fluid flesh: and long before the time of this celebrated physician, Paul Zacchia asserted that "*caro nihil aliud est quam sanguis concretus*" (*Quest. Legalis*, p. 239). This fibrous matter is more animalized than the lymph; and it appears to be prepared by the very act

of circulation to concur in augmenting the parts of the human body.

Blood contains much iron. The experiments of Menghini, Bucquet, and Lorry, prove that this metal is capable of passing into the blood by the first passages, since patients who are under a course of martial medicine void it by the way of urine. When the coagulated part of the blood has been washed, if that part which has retained the colouring matter be burned, and the coal be lixiviated, the residue of this lixivium is in the state of saffron of mars, of a fine colour, and usually obedient to the magnet.

The colour of blood has been attributed to iron; and it is very true that the colour appears to be entirely formed of it, for there exists no vestige of this metal in the washed and discoloured coagulum; but as, on the other hand, the blood does not become coloured without the concurrence of air, and as oxigene alone is absorbed in respiration, it appears that the colour is owing to iron calcined by the pure air, and reduced to the state of red oxide.

From this manner of conceiving the phenomenon, we may perceive why animal substances are so advantageous in assisting and facilitating the red dye, and why these substances take colours more easily.

C H A P. IV.

Concerning Fat.

FAT is a condensed inflammable juice contained in the cellular membrane : its colour is usually white, but sometimes yellow ; its taste insipid ; and its consistence more or less firm, in the various species of animals. In cetaceous and other fish, it is nearly fluid ; in carnivorous animals the fat is more fluid than in frugivorous animals, according to Mr. De Fourcroy. In the same animal it is more solid near the kidneys, and under the skin, than in the vicinity of the moveable viscera ; as the animal grows old, the fat becomes yellow, and more solid. Consult De Fourcroy. To obtain fat in a state of purity, it is cut into small pieces ; the membranes and smaller vessels are separated ; it is washed, then fused with a small quantity of water, and kept in fusion till all the water is evaporated. This last fluid which floats above it, boils ; and when the ebullition ceases, it is a proof that all the water is dissipated.

Fat has the greatest analogy with oils. Like them

them it is not miscible with water ; it forms soaps with alkalis ; and burns in the open air, by the contact of an ignited substance, at a sufficient heat.

Neumann treated the fat of the goose, of the hog, of the sheep, and of the ox, in a glass retort by a graduated fire. He obtained phlegm, an empyreumatic and brownish oil, and a brilliant coal. He concludes from his analysis that there is little difference between fats ; and that that of the ox appears only to contain a little more earthy matter. This very imperfect analysis throws no light on the nature of fat ; and we are indebted to Messrs. Segner and Crell for experiments of a much more interesting kind. We shall relate the chief.

1. Beef suet distilled on the water-bath, in a glass retort, affords oil and phlegm ; it forms soaps with potash : the reddish phlegm has an acid taste ; effervesces with alkali, without reddening the syrup of violets, which assumes a brown colour by this mixture.

2. The marrow of beef affords the same products, excepting that a substance first passes over of the consistence of butter. The phlegm has no smell when cold. Fixed alkali occasions a weak effervescence.

M. Crell has instructed us in the means of obtaining

obtaining a peculiar acid from fat, which is at present distinguished by the name of the Sebacic Acid.

He at first attempted to concentrate this acid by distilling off the phlegm ; but this did not succeed, for the liquid in the receiver was as acid as that in the retort. He then saturated all the acid with potash, and obtained a brownish salt by evaporation, which he fused in a crucible, to burn the oil which contaminated it. This salt, by solution and evaporation, afforded a foliated salt. He poured four ounces of sulphuric acid upon ten ounces of the salt, and distilled by a very gentle fire. The sebacic acid passed over in the form of a greyish vapour ; and half an ounce, very fuming and acrid, was found in the receiver. Crell observes that, in order to succeed in this operation, the salt must be kept a long time in fusion, without which the acid would be mixed with oil, which weakens its virtue.

By distillation of fat in a copper alembic, Mr. Crell obtained the pure acid. But the fire necessary for this purpose alters the vessel, causes the tin to run off, and the acid itself becomes charged with copper.

It has long been known that the alkalis form a kind of soap with animal fat. Mr. Crell,

Crell, by treating this soap with a solution of alum, separated the oil, and obtained the sebate of potash by evaporation: the sulphuric acid afterwards distilled from this salt, decomposes it; and by this means the sebatic acid is separated.

Mr. De Morveau melted suet in an iron pot; and to this he added pulverized quicklime, taking care to stir it continually at the commencement; at the end of the operation, a considerable heat was applied, taking care to raise the vessels, in order to avoid exposure to the vapours. When the whole was cold, it was found that the suet had no longer the same solidity. This was boiled in a large quantity of water; and the lixivium, after filtration, afforded a brown acrid salt, which is the sebate of lime. This salt is soluble in water, but would require too much time to purify it by repeated crystallizations. This purpose is more easily answered by exposing it to a degree of heat capable of burning the oil; after which, a single solution is sufficient to purify it. It leaves its oil upon the filtre in the state of coal; and nothing more is then necessary than to evaporate it.

The solution usually contains a small quantity of quicklime, which may be precipitated by the carbonic acid. This salt, treated in the same

same manner as the sebate of potash, affords the sebacic acid,

This acid exists ready formed in suet : two pounds afforded somewhat more than seven ounces to Crell. It exists ready formed in the fat, since earths and alkalis disengage it.

It has the greatest affinity with the muriatic acid, as it forms with potash a salt which melts in the fire without being decomposed: it acts powerfully on gold, when mixed with nitric acid; it precipitates silver from the nitrate of silver; it forms a sublimate with mercury, and the solution of this sublimate is not rendered turbid by the muriate of soda. But though this acid approaches the muriatic in several respects, it differs from it in others, and hitherto seems to be nothing but a modification of that acid. With soda, it forms crystals in needles, and a crystallized salt with lime. It decomposes common salt, &c.

Mr. Crell obtained the acid of fat by distillation from the butter of cacao. Spermaceti likewise affords it.

The properties of this acid are the following:

It reddens blue vegetable colours.

It assumes a yellow colour by fire, and leaves a residue, which announces a partial decomposition.

fition. From this circumstance, Mr. Crell considers it as occupying the middle space between the vegetable acids which are destroyed by fire, and the mineral which receive no alteration. Its existence in the butter of cacao, and in fats, is favourable to the notion of Crell on this subject.

It attacks the carbonates of lime and alkali with effervescence, and with them forms salts which Bergmann finds to be very similar to the acetites with the same basis.

This acid, as Mr. De Morveau observes, seems to have some action upon glass. Mr. Crell having digested it several times upon gold, always obtained a precipitate of white earth, which was not lime, but which he presumes to have been carried up in the distillation, and could only arise from the retort itself.

This acid does not perceptibly act on gold; but it attacks the oxide, and forms a crystallizable salt, as it does likewise with the precipitates of platina.

It unites with mercury and with silver; yielding the latter to the muriatic acid, but not the former: it takes both from the sulphuric acid, lead from the nitric and acetous acids, and tin from the nitro-muriatic acid.

It attacks neither bismuth, cobalt, nor nickel.

It

It does not decompose the sulphates of copper, of iron, or of zinc; nor the nitrates of arsenic, manganese, zinc, &c.

It reduces the oxide of arsenic by distillation. Crell formed a sebacic ether.

From this analysis it appears that fat is a kind of oil or butter rendered concrete by an acid.

Its uses are—1. To keep up the heat of the body, and defend the viscera from the impression of external cold. 2. To serve as nourishment or support for the animal on the occasions of want, sickness, &c.

C H A P. V.

Concerning the Bile.

THE Bile is one of those humours which it is essential to know, on account of the influence and effect it has both in the states of health and disorder. We shall even see that its analysis is sufficiently perfect to afford instruction in an infinity of cases.

This humour is separated in a large viscus of the lower belly, called the Liver; it is afterwards deposited in a bladder, or reservoir, called the Gall Bladder; from which it is conveyed

conveyed into the duodenum by a particular channel.

The bile is glutinous, or imperfectly fluid, like oil; of a very bitter taste; a green colour, inclining to yellow; and froths by agitation like the solution of soap.

If it be distilled on the water-bath, it affords a phlegm, which is neither acid nor alkaline, but putrefies. This phlegm, according to the observation of Mr. De Fourcroy, often emits a smell resembling that of musk: bile itself has the same property, according to the general observation of butchers. When the bile has given out all the water it is capable of affording upon the water-bath, the residue is a dry extract, which attracts the humidity of the air, is tenacious, pitchy, and soluble in water. By distillation in a retort, it affords ammoniac, an empyreumatic animal oil, concrete alkali, and inflammable air. The coal is more easily incinerated than that we have last treated of. It contains iron, carbonate of soda, and phosphate of lime.

All the acids decompose bile; and disengage an oily substance, which rises to the top. The salts afterwards obtained by evaporation, have soda for their basis; which shews that the bile is a true animal soap. The oil which is com-
bined

combined with soda is analogous to resins, is soluble in spirit of wine, &c.

The metallic solutions decompose bile by double affinity, and produce metallic soaps.

Bile unites with oils, and cleans stuffs in the same manner as soap.

Bile is soluble in alcohol, which separates the albuminous principle. It is this last substance which renders bile coagulable by fire and by acids; and it is this likewise which hastens its putrefaction.

The constituent principles of bile are, water, a spiritus rector, a lymphatic substance, a resinous oil, and soda. Mr. Cadet has found a salt in it, which he thought similar to sugar of milk; this salt is probably no other than that which was discovered by Mr. Poullétier.

Bile is therefore a soap, resulting from the combination of soda with a matter of the nature of resins, and a lymphatic substance, which renders it susceptible of putrefaction and coagulation. This substance gives the bile the character of animalization, diminishes its acidity, and favours its mixture with the other humours. The saline part renders the bile more fluid and soluble in water; and it is more acrid the more this principle abounds.

The resinous part differs from vegetable resins—

fins—1. Because these do not form soap with fixed alkalis. 2. Because they are more acrid and more inflammable. 3. Because the animal resin melts at the temperature of 40 degrees, and acquires a fluidity similar to that of fat; from which however it differs in not being soluble in alcohol, in which respect it approaches to spermaceti.

The acids which act upon bile in the first passages, decompose it. The greenish yellow colour of the excrements of infants at the breast, arises from a similar decomposition; and it is the resinous part which tinges them. From the action of the bile upon acids, we may deduce the effect of these remedies when the evacuations are putrid, and the degeneration of the bile is septic. The lymph is then coagulated, and the excrements become harder. This shews the reason why the excrements of infants are so frequently clotted.

When the bile remains a long time in the first passages, as for example in chronical disorders, it assumes a black colour, becomes thick, acquires the consistence of an unguent, and forms a lining of several lines in thickness in the intestinal canal, according to the observation of Mr. De Fourcroy. When smeared on paper, and dried, it becomes green; diluted with water,

water, it forms a tincture of a yellow green colour, from which a large quantity of black scales are precipitated: with alcohol it likewise forms a black tincture, and deposits that laminated brilliant salt discovered in biliary calculi by Mr. Poulletier de la Salle. This humour, which forms the atra bilis of the ancients, is nothing but the bile rendered thick; and in this case the effect of acids, and the danger of irritating substances, may be easily accounted for. This thickening of the bile clogs the viscera of the lower belly, and produces obstructions.

Many disorders are referable to the predominant character of the bile. On this subject, the interesting Memoirs of Mr. De Fourcroy may be consulted, in the collection of the Royal Society of Medicine for the years 1782 and 1783.

When the bile becomes thick in the gall bladder, it forms the concretions called biliary calculi. Mr. Poulletier has paid great attention to the analysis of these stones. He has observed that they are soluble in ardent spirit. When the solution is left to itself for a certain time, brilliant and light particles are seen in it, which Mr. Poulletier found only in the human

man calculi, and which appeared to him to have the greatest analogy with the salt of benzoin.

Mr. Fourcroy has observed that the discovery of Mr. De la Salle has been confirmed by the Royal Society (of Medicine), which has received several biliary calculi that appeared to be formed by a salt analogous to that which was observed by this chemist. They consist of masses of transparent crystalline plates, similar to mica or talc. The Society of Medicine possesses in its collection a gall bladder entirely filled with this saline concretion.

We may therefore, as Mr. De Fourcroy observes, admit of two kinds of calculi: the one are opaque, and are afforded only by the condensed bile; the others, consist of the crystals we have described.

Boerhaave observed, long since, that the gall bladder of oxen, at the end of the winter, was filled with calculi, but that the fresh pasturage dissipated these concretions.

Soaps have been proposed as solvents for these calculi. The Academy of Dijon has published the success of a mixture of essence of turpentine and ether. Fresh vegetables, which are such sovereign remedies in destroying these concretions, owe their virtue perhaps to the circum-

circumstance that they develop an acid in the stomach, as we have observed in treating of the gastric juice:

The use of the bile, in the animal œconomy, consists, no doubt, in dividing those substances which have undergone a first digestion in the stomach; and in giving efficacy and force to the motion of the intestines. When its flux is interrupted, it abounds in the blood, and the whole body becomes of a yellow tinge.

The bile or gall is an excellent vulnerary, externally applied: internally taken, it is a good stomachic, and one of the best deobstruents the art of medicine possesses. This kind of remedies deserves the preference, as being more analogous to the constitution; and bile is a proper medicine when the digestion languishes, or the viscera of the lower belly are clogged.

Bile, like other soaps, removes spots of oil, or other greasy matter, from substances to which they are adherent.

C H A P. VI.

Concerning the Soft and White Parts of Animals.

THESE parts are perhaps less known than those of which we have just treated ; but their analysis is not less interesting : we may even affirm that it is more so ; because the application of the knowledge we may acquire on this subject, will daily present itself in the commonest purposes of domestic life.

All the parts of animals, whether membranes, tendons, aponeuroses, cartilages, ligaments, or even the skin and horns, contain a mucous substance very soluble in water, but not in alcohol, and known by the name of Jelly. Nothing need be done to obtain it, but to boil these animal substances in water, and concentrate the decoction, until by mere cooling it assumes the form of a solid tremulous mass.

Jellies are very common in our kitchens ; and the cooks are perfectly well-acquainted with the methods of making them, and of giving them solidity when the temperature of the atmosphere is very hot. The jelly of harts-horn is extracted by a similar operation, and afterwards rendered

rendered white with the milk of almonds. This kind of food, duly scented, is served up at our tables by the name of *blanc manger*. Jellies are in general restorative and nourishing: that of harts-horn is astringent and emollient.

Jellies in general have no smell in their natural state, and their taste is insipid. By distillation they afford an insipid and inodorous phlegm, which easily putrefies. A stronger heat causes them to swell up, become black, and emit a fetid odour, accompanied with white acrid fumes. An alkaline phlegm then passes over, succeeded by an empyreumatic oil, and a little carbonate of ammoniac. A spongy coal remains, which is with difficulty reduced to ashes, and affords by analysis muriate of soda and phosphate of lime.

Jelly cannot be kept above a day in the summer, or two or three in the winter. When it becomes spoiled, white livid spots are formed on its surface, which speedily extend to the bottom of the pots. A large quantity of nitrogenous, hydrogenous, and carbonic gas is emitted.

Water dissolves jellies perfectly. Hot water dissolves a large quantity, as they become consistent only by cooling. Acids likewise dissolve them, and alkalis more especially do.

The nitric acid disengages nitrogene gas, according to the fine experiments of M. Berthollet.

When jelly has been extracted without long decoction, and has no lymph mixed with it, it then possesses most of the characters of the vegetable jelly: but it is seldom obtained without a mixture of lymph; and in this case it essentially differs from the vegetable jellies, in affording nitrogene gas and ammoniac.

If jelly be concentrated to such a degree as to give it the form of a cake, it is deprived of the property of putrefying; and by this means the dry or portable soups are formed, which may be of the greatest advantage in long voyages. The following is a receipt for preparing these cakes:

Calves feet	-	4
Leg of beef	-	12 pounds,
Knuckle of veal		3 pounds,
Leg of mutton	-	10 pounds,

These are to be boiled in a sufficient quantity of water, and the scum taken off as usual; after which the soup is to be separated from the meat by straining and pressure. The meat is then to be boiled a second time in other water; and the two decoctions, being added together, must be left to cool, in order that the fat may be exactly separated. The soup must
then

then be clarified with five or six whites of eggs, and a sufficient quantity of common salt added. The liquor is then strained through flannel, and evaporated on the water-bath to the consistence of a very thick paste; after which it is spread rather thin upon a smooth stone, then cut into cakes, and lastly dried in a stove until it becomes brittle: these cakes are kept in well closed bottles. The same process may be used to make a portable soup of the flesh of poultry; and aromatic herbs may be used as a seasoning, if thought proper.

These tablets or cakes may be kept four or five years. When intended to be used, the quantity of half an ounce is put into a large glass of boiling water, which is to be covered, and set upon hot ashes for a quarter of an hour, or until the whole is entirely dissolved. It forms an excellent soup, and requires no addition but a small quantity of salt.

The cakes of hockiac, which are prepared in China, and are known in France by the name of *colle de peau d'âne*, are made with animal substances. They are used in disorders of the lungs, in the dose from half a dram to two drams.

The nature of the substance made use of, and the method of operating, produce some difference in these products. Old or lean
animals

animals afford in general a better glue than the young and fat. For a full account of the art of making glue, consult *L'Art de faire différentes Espèces de Colle, par M. Dubamel de Monceau, de l'Académie des Sciences.*

1. To make the strong or English glue, the parings of leather, the skins of animals, with the ears of oxen, calves, sheep, &c. are used. These matters are first digested in water, to penetrate the texture of the skins; they are afterwards steeped in lime water, taking care to stir and agitate them from time to time; they are then laid in a heap for some time, afterwards washed, and the superabundant water pressed out by a press. These skins are then digested in water gradually heated to ebullition. The liquor is afterwards poured out, and separated with pressure. Lastly, it is thickened by evaporation of the water by heat, and poured on flat polished stones, or into moulds, and left to dry and harden.

This glue is brittle. It is softened by heating it with a small quantity of water for use, and is applied with a brush. Carpenters and cabinet-makers use it to fasten pieces of wood together.

2. The glue of Flanders is merely a diminutive of the strong glue. It has not the same consistence, and cannot be used in glueing wood; it is thinner and more transparent than the
the

the former. It is made with a more accurate choice of materials, and with greater care. It is used by designers. Mouth glue is made of this, to stick paper together, by fusing it again with the addition of a small quantity of water, and four ounces of sugar-candy, to a pound of the glue.

3. The colle de gand is made with the clippings of white gloves, well steeped in water, and boiled: it is likewise made with the clippings of parchment. In order that these two kinds of glue may be fit for use, it is necessary that they be of the consistence of a tremulous jelly when cold.*

4. Fish-glue, or isinglass, is made of the mucilaginous parts of a large fish commonly found in the Russian seas. The skin, the fins, and the nervous parts, are cut into slices, boiled on a slow fire to the consistence of jelly, spread out to the thickness of a sheet of paper, and formed into cakes or long pieces, such as we receive them from Holland. The silk manufacturers, and more especially the ribbon weavers, use it to give a lustre to their goods: it is also used to stiffen gauzes; and to clarify or fine wine, by mixing a solution of this sub-

* These weaker glues are called size by our workmen, who apply the name of Glue to the strong glue only. T.

stance with it. Isinglass enters into the composition of some plasters. It is excellent to correct acrid humours, and terminate obstinate venereal disorders.

Gilders' size is made by boiling eel-skins in water with a small quantity of lime: the water is strained off, and some whites of eggs added. When it is intended to be used, it is heated, applied to the surface intended to be gilded, and when it is dry the gold leaf is laid on.

5. The glue of snails is made by exposing snails to the sun, and receiving in a glass the fluid which flows from them. This liquor is mixed with the juice of milk thistle. It is used to cement glasses together, which are afterwards exposed to the sun to dry.

6. To make the glue of parchment, or parchment size, two or three pounds of the clippings of parchment are put into a pail of water. These are boiled until half the water is evaporated; after which the whole is strained through a cloth, and left to settle.

The glue or size used in the paper manufactories, to fortify the paper, and to repair its defects, is made with wheat flour diffused in boiling water, and strained through a sieve. This size must be used the following day, and neither sooner nor later. The paper is afterwards beat
with

with a mallet, sized a second time, put into the press to smooth and unite it, and afterwards extended by hammering.

C H A P. VII.

Concerning the Muscular or Fleſhy Parts.

THE muscles of animals are formed of longitudinal fibres connected together by the cellular membrane, and impregnated with various humours, in which we find partly those we have already examined separately.

The analysis of these substances by distillation, afforded us little instruction respecting their nature. The products were, water which easily became putrid, alkaline phlegm, empyreumatic oil, carbonate of ammoniac, and a coal which afforded by incineration a small quantity of fixed alkali, and febrifuge salt.

The process which succeeds the best for separately obtaining the various substances which compose muscles, is the following, which has been pointed out to us by Mr. De Fourcroy.

1. The muscle is first washed in cold water: by this means the colouring lymph, and a saline substance,

substance, are taken up. By slow evaporation of this water, the lymph coagulates, and may be separated by the filtre; and a continuance of the evaporation affords the saline matter.

2. The residue of the first washing is digested in alcohol, which dissolves the extractive matter, and a portion of the salt: the extract is separated by the evaporation of the alcohol.

3. The residue of these first operations is to be boiled in water, which takes up the jelly, the fat part, and the remaining saline and extractive matters. The fat oil swims on the surface, and may be taken off.

4. After these operations, there remains only a white insipid fibrous substance, insoluble in water; which contracts by heat, like other animal substances; affords ammoniac, and very fetid oil, by distillation. Nitrogen gas is obtained from it by the nitric acid. It possesses all the characters of the fibrous part of the blood, in which fluid it is formed, to be afterwards deposited in the muscles, where it receives the last character appropriated to it.

Mr. Thouvenel, to whom we are indebted for interesting researches on this subject, has found in flesh a mucous extractive substance, soluble in water and in alcohol, possessing a peculiar taste which jelly has not; and when
this

this substance is very much concentrated, it assumes an acrid and bitter taste. Fire develops an aromatic flavour in it. This substance, evaporated to dryness, assumes a bitter, acrid, and saline taste. It swells up upon hot coals, and liquefies; emitting an acid penetrating smell, resembling that of burned sugar. It attracts the humidity of the air, and forms a saline efflorescence. In a hot atmosphere it becomes sour, and putrefies. All these characters indicate a resemblance between this substance, the saponaceous extracts, and the saccharine matter of vegetables. Mr. Thouvenel, who has likewise analysed the salt obtained by the decoction and slow evaporation of flesh, obtained it sometimes in the form of down, and sometimes in that of crystals, whose figure he could not describe. This salt appeared to him to be a phosphate of potash in frugiverous quadrupeds, and a muriate of potash in carnivorous reptiles. It is probable, as Mr. De Fourcroy observes, that this salt is a phosphate of soda or of ammoniac, mixed with the phosphate of lime. These salts are indicated, and even with excess of acid, like those of urine, by lime-water and ammoniac, which form white precipitates in the decoction of flesh.

The most abundant part of muscles, and that
which

which constitutes their predominating character, is the fibrous matter. The characters which distinguish this substance are—

1. It is not soluble in water.
2. It affords more nitrogene gas by the nitric acid than other substances do.
3. It afterwards affords the oxalic acid, and the malic acid.
4. It putrefies easily when moistened, and affords much concrete ammoniac by distillation.

The other three substances contained in flesh, namely the lymph, the jelly, and the fat part, are the same substances concerning which we have already treated under the same denominations.

From these principles we may give the etiology of the formation of soup, and follow the successive disengagement of all the principles we have spoken of.

The first impression of the fire, when a soup is made, is the disengagement of a considerable scum, which is taken off until it no longer appears. This scum arises merely from the disengagement of the lymph, which coagulates by the heat. It assumes, by the impression of the fire, a red colour, which it does not naturally possess.

At the same time the gelatinous part is disengaged, which remains dissolved in the soup,
and

and congeals only by cooling. It forms on the surface of cold soup a body more or less thick, according to the nature of the substances, and the age of the animals; for young animals afford a larger quantity than such as are old.

As soon as the flesh is penetrated by heat, flat round drops arise, and float at the surface of the fluid, in which they are not afterwards dissolved, but congeal by cooling, and exhibit all the characters of fat.

In proportion as the digestion proceeds, the mucous extractive part separates; the soup becomes coloured, assumes its peculiar odour and taste; and it is more particularly to this principle that its properties are owing.

The salt which is at the same time dissolved takes off the insipidity of all the before-mentioned principles; and at this period the soup is completely made.

According to the nature of the several principles which are disengaged, and the order in which they appear, it is evident that the management of the fire is not a matter of indifference. If the ebullition be hastened, and a proper time be not allowed for the disengagement of the mucous extractive matter, the three inodorous and insipid principles are obtained;
and

and this is observed in soups made by cooks who are hastened, or have not time allowed to pay a due attention to their work. When, on the contrary, the digestion is made over a slow fire, the principles separate one after the other, in order; the skimming is more accurately performed; the aromatic flavour which is disengaged combines more intimately, and the soup is of an excellent flavour. These are the soups of the good women who perform better with a small quantity of meat, than professed cooks with their usual prodigality; and in this case we may say that the form is of more value than the substance.

The heat must not be applied too long; for the great evaporation, by concentrating the principle of smell and taste, at the same time with the salt, renders them acrid and bitter.

C H A P. VIII.

Concerning Urine.

URINE is an excrementitious humour of the body: and it is one of the fluids of which it is of the greatest importance to possess an accurate knowledge; because the practical physician

physician may derive the greatest advantage from information of this nature. It is known to what a degree of extravagance the marvellous pretensions of this kind have been carried. The delirium has proceeded to such a height, as even to pretend to ascertain from the urine, not only the nature of the disorder, and the character of the patient, but likewise the sex and condition.

The true physician has never given into this excess: but he has always derived assistance, in his practice, from the characters exhibited by the urine; and this is the humour from which he may draw the most satisfactory indications. It carries out, as we may say, the internal character; and a physician who knows how to form a judgment upon its properties, may deduce the most instructive consequences from it. *Monro*, in his *Treatise of Comparative Anatomy*, has described the organs which, in birds, supply the place of the kidneys: they are placed near the vertebral column; and communicate, by two ducts, to the vicinity of the anus. He affirms that the urine of birds is that whitish substance which almost always accompanies the excrements.

Chemical analysis ought to enlighten the physician in his researches concerning the urine.

The

The nature of the principles it carries off in certain circumstances, affords vast information respecting the predominant principle in the fluids of the human body. Its various states shew the disposition of the constitution. Persons of a very irritable habit have the urine of a lighter colour than others; gouty persons evacuate turbid urine; and it has been observed that, when the bones become soft, the urine carries off the phosphate of lime, which constitutes their basis; instances of which were observed in the persons of Mrs. Supiot, the widow Melin, &c. The various states of any disorder are always pointed out by the state of the urine; and the truly practical physician will there observe signs of crudity and concoction which will direct his proceedings.

Urine is likewise an humour interesting to be known on account of the various uses to which it is applied in the arts. It was from this substance alone that phosphorus was, for a long time, extracted; it is to this fluid that we owe the development of the blue colour of turnsole, and the violet of archil; it may be successfully employed in forming artificial nitre-beds; it powerfully contributes to the formation of sal ammoniac; it may be used to prepare the alkali in the manufacture of Prussian

fiat blue; and, in a word, it may be applied in all the operations wherein the concurrence of an animal humour is required.

Urine, in its natural state, is transparent, of a citron yellow colour, a peculiar smell, and a saline taste.

It is more or less abundant, according to the seasons, and the state of the individual. It is sufficient to observe, on this subject, that transpiration, and more particularly perspiration or sweat, supply the place of the secretion of urine; and that consequently, when the transpiration is great, the urine is not abundant.

Physicians distinguish two kinds of urine. The one is emitted one or two hours after drinking; this is aqueous, contains scarcely any salts, and has neither colour nor smell: it is this which is evacuated so plentifully during a course of mineral waters. The other is not evacuated until after the functions of sanguification are finished; and may be called *Fæces Sanguinis*. This has all the characters we have enumerated and assigned to urine. It is carried by the arteries into the kidneys, where it is separated, and poured into the receptacles of these organs, whence it passes, by the ureters, into the bladder; where it remains a longer or shorter time according to the habitude of

the person, the nature of the urine, the irritability or magnitude of the bladder itself.

The urine has been long considered as an alkaline fluid; but in our time it has been proved to contain an excess of acid. It appears from the experiments of M. Berthollet—

1. That this acid is of the nature of the phosphoric acid. 2. That the urine of gouty persons contains less of this acid; whence he conjectures, with reason, that this acid retained in the blood, and conveyed into the articulations, produces an irritation, and consequently a flux of humours, which cause pain, and swelling.

The analysis of urine by distillation has been accurately made by various chemists, but more especially by Rouelle the younger. Much phlegm is obtained, which putrefies with the greatest facility, and affords ammoniac by its putrefaction, though it does not itself contain that substance. At the same time a substance is precipitated of an earthy appearance, but which in reality is a true phosphate of urine. It is this same salt which forms the sediment of urine, which is observed by exposing it to cold during the winter, even though the urine be of a person in perfect health. When urine has, by a sufficient evaporation, acquired the consistence of syrup, it need only be exposed,
in

in a cool place, to obtain crystals, in which analysis has proved the existence of the phosphates of soda and of ammoniac. This precipitate of crystals has been distinguished by the name of fusible salt, native salt, microcosmic salt. Urine may be deprived of all saline matter by repeated solutions, filtrations, and evaporations; the matter which adheres to these crystals, and of which they may be cleared by these operations, is soluble, partly in alcohol, and partly in water. The saponaceous substance, or that which is soluble in alcohol, is capable of crystallization, dries difficultly, and affords by distillation a small quantity of oil, of carbonate of ammoniac, of muriate of ammoniac, and the residue converts syrup of violets to a green. The extractive principle is easily dried, and exhibits the same phenomena in distillation as animal substances. See Rouelle.

The phenomena exhibited by the spontaneous decomposition of urine are very interesting to be known; on which subject an excellent memoir of Mr. Halle, in the volume of the Society of Medicine for 1779, may be consulted. Urine left to itself soon loses its smell, which is succeeded by a smell of ammoniac, which is likewise dissipated in its turn. The colour becomes brownish, and the smell fetid

and nauseous. We are indebted to Mr. Rouelle for a valuable observation—that crude urine, *urina potūs*, presents very different phenomena; and that it becomes covered with mouldiness, like the expressed juices of vegetables. Putrefied urine has much less acid in the disengaged state than when it is fresh.

The fixed alkalis and lime disengage much ammoniac from urine, by decomposing the phosphate of ammoniac.

The acids destroy the smell of urine by combining with the ammoniac, which is the principal vehicle of that smell.

We may therefore consider urine, in its natural state, as water holding in solution matters purely extractive, and phosphoric or muriatic salts. These phosphoric salts have lime, ammoniac, or soda, for their basis: we shall take a slight view of each in particular.

That which is called fusible salt, is nothing but a mixture of all the salts contained in urine, clogged with the extractive principle. All the ancient chemists advised evaporation, and repeated filtration, to clear them from this animal extract; but Messrs. Rouelle and the Duke de Chaulnes have observed, that great part of the salt is disengaged and dissipated by these operations to such a degree, that three-fourths

arc

are lost. To avoid most of this loss, the Duke de Chaulnes advises solution, filtration, and cooling in well-closed vessels. Two strata of salt are then obtained; the upper of which appears to have the form of square tables, wherein Rouelle observed tetrahedral prisms flattened with dihedral summits. This is the phosphate of soda: and beneath this lies another salt crystallized in regular tetrahedral prisms, and is the phosphate of ammoniac.

1. The phosphate of ammoniac usually exhibits the form of a very compressed tetrahedral rhomboidal prism: but this form varies much; and the mixtures of the phosphate or muriate of soda cause an infinity of modifications in it.

The taste of this salt is cool, afterwards urinous, bitter, and pungent.

This salt swells up upon the coals, emits a strong smell of ammoniac, and melts by the blow-pipe into a very fixed and very fusible glass.

It is soluble in water. Five parts of cold water, at ten degrees of Reaumur, dissolved only one of this salt; but at the temperature of sixty degrees this salt is decomposed, and a portion of its acid is volatilized.

It serves as a flux to all the earths; but in this case its alkali is disengaged, and the phosphoric

phoric acid unites with the earth, as I find by experiment. Bergman proposed it as a flux. The fixed alkalis and lime-water disengage the ammoniac.

When this salt is heated with charcoal, it affords phosphorus.

2. The phosphate of soda was made known in 1740 by Haupt, under the name of *sal admirabile perlatum*. Hellot before him, and Pott seventeen years after him, took it for selenite. Margraaf gave an accurate description of it in his *Memoirs*, in 1745; and Rouelle the younger described it at full length in 1776, under the name of fusible salt with base of natrum. All agree that it differs from the preceding in not affording phosphorus with charcoal.

According to Rouelle, its crystals are flattened irregular tetrahedral prisms, with dihedral summits. The four sides of the prism are two irregular alternate pentagons, and two long rhombi truncated slopewise.

When exposed to heat it fuses, and affords a glass which becomes opaque by cooling.

It is soluble in distilled water, and the solution turns syrup of violets green.

It does not afford phosphorus with charcoal.

Lime disengages the soda. It may even be obtained in a caustic state, if the precipitation be effected by lime-water.

The

The mineral acids, or even distilled vinegar, decompose it by seizing its alkali. Mr. Proust, to whom we are indebted for all the accurate information we possess concerning these substances, was of opinion, that the base to which the soda adhered was not the phosphoric acid, but a very singular salt, whose properties greatly resembled those of the acid of borax. He found this salt in the mother water, after having decomposed the phosphate of soda by the acetic acid, and obtained the acetite of soda by crystallization. He obtained this same salt by dissolving and evaporating the residue of the distillation of phosphorus. One ounce of phosphoric glass contains five or six drams. This salt was characterized by the following properties:

1. It crystallizes in parallelograms.
2. Its taste is alkaline, and it turns syrup of violets green.
3. It swells up in the fire, reddens and melts.
4. It effloresces in the air. This may not take place when the phosphoric acid has not been sufficiently decomposed by the distillation to leave the alkali disengaged, as I have observed.
5. Boiling water dissolves six gros per ounce.
6. It assists the vitrification of earths, and forms a perfect glass with flux.

7. It

7. It decomposes nitre and marine salt, and separates their acids.

8. It is insoluble in alcohol.

Mr. Klaproth has published in *Crell's Journal* an analysis of the fusible salt, in which he has shewn that the pearly salt, or salt of Proust, is merely the phosphate of soda. To prove this, nothing more need to be done than to dissolve this salt in water, and to add a solution of nitrate of lime. The nitric acid seizes the soda, and the phosphoric acid is precipitated with the lime. The phosphoric acid may afterwards be separated by means of the sulphuric acid.

If the phosphoric acid obtained by the slow combustion of phosphorus be saturated with soda slightly in excess, the fusible salt is formed; if this excess be taken up by vinegar, or if more phosphoric acid be added, the substance described by Proust is formed.

The phosphate of soda is not decomposable by charcoal; and it is at present clearly seen why the fusible salt affords but little phosphorus; and why Kunckel, Margraaf, and others recommended a mixture of the muriate of lead: for by this means the phosphate of lead was formed, which permits the decomposition of the phosphoric acid, and affords phosphorus.

Con-

Concerning the Calculus of the Bladder.

Paracelsus made some researches concerning the calculus of the bladder, which he calls *duellech*. He considers it as a substance intermediate between tartar and stone, and thinks that its formation is owing to the modification of an animal resin: he supposes it to be absolutely similar to the matter of the gout.

Vanhelmont does not admit of this analogy; and considers the calculus as an animal coagulum produced by the salts of urine, and a volatile earthy spirit. Boyle found this calculus to be composed of oil and volatile salt. Boerhaave supposed it to consist of a subtle earth, intimately united with alkaline volatile salts. Hales has observed that a calculus of the weight of two hundred and thirty grains afforded six hundred and forty-five times its volume of air, and that there remained only a calx of the weight of forty-nine grains.

Independent of this chemical information, some physicians, such as Alston, De Haen, Vogel, Meckel, &c. had observed the solvent power of soap, lime-water, and alkalis.

But we possessed no accurate ideas on this subject until it was seriously taken up by Scheele
and

and Bergman. The bezoar of the bladder is formed for the most part of a peculiar concrete acid, which M. De Morveau calls the Lithiatic Acid. (The *Encyclopédie Méthodique* may be consulted, from which the present article is an extract.)

The calculus is partly soluble in boiling water. The lixivium reddens the tincture of turnsole; and by cooling deposits most of what it had dissolved. The crystals thus separated are the concrete lithiatic acid.

Scheele has likewise observed—1. That the sulphuric acid does not dissolve the calculus unless assisted by heat, and that it is then converted into the state of sulphureous acid. 2. That the muriatic acid has no action upon it. 3. That the nitric acid dissolves it with effervescence, and disengages nitrous gas and carbonic acid. This solution is red; it contains a disengaged acid, and tinges the skin of a red colour. This solution is not precipitated by the muriate of barytes, nor rendered turbid by the oxalic acid. 4. That the calculus was not attacked by the carbonate of potash; but that the caustic alkali dissolved it, as well as the volatile alkali. 5. That one thousand grains of lime-water dissolved 5,37 by mere digestion, and that it was again precipitated by acids. 6. That

6. That all urine, even that of infants, held a small quantity of the matter of calculus in solution; which may perhaps be the cause that, when this matter finds a nucleus in the bladder, it more easily incrusts it. I have seen a calculus with a large plum stone in its centre. 7. That the brick-coloured deposition from the urine in fevers, is of the nature of the calculi.

These experiments exhibit several important consequences with regard to the composition of the calculus, and the properties of the lithic acid.

The calculus contains a small quantity of ammoniac. The coaly residue of the combustion indicates an animal substance of the nature of jelly. The celebrated Scheele did not find it to contain a particle of calcareous earth; but Bergman precipitated a true sulphate of lime, by pouring the sulphuric acid into the nitrous solution of the calculus. He admits that the lime is very small in quantity, as it rarely exceeds the two-hundredth part of the entire weight. The same chemist has detected a white spongy substance, not soluble in water, nor attacked by spirit of wine, or acids, or alkalis; which at last affords a coal of difficult incineration, and which the nitric acid does not dissolve, even in the state of ashes; but this matter

ter exists in so small a quantity, that he could not procure enough to examine it. The calculus is not therefore analogous to bones in its nature; neither is it a phosphate of lime, as has been pretended. These are the results of the chemists of the north; but I must observe that, after having decomposed many calculi by the caustic alkali, I have precipitated lime, and formed phosphates of potash.

Some physicians, such as Sydenham, Cheyne, Murray, &c. have thought that the arthritic concretions were of the same nature as the calculus. The use which Boerhaave made of alkalis in the gout; the virtues admitted by Fred. Hoffmann in the thermal waters of Carlsbad, which contain soda, with an excess of carbonic acid; the authority of Springsfeld, who asserts that the calculus is very speedily dissolved in these waters, even in the urine of those who drink them; the success of lime-water, used by Alston in the gout—all conspire to give some credit to the opinion of these early physicians. But the following experiments do not agree with this notion,

Vanfwieten affirms that the arthritic concretion never acquires the hardness of the calculus. Pinelli (*Philos. Trans.*) distilled in a retort three ounces of the arthritic matter collected

lected from the articulations of several gouty persons; and he obtained ammoniac, with some drops of oil, the residue weighing two gros. This residue, which was soluble in the muriatic, sulphuric, and acetic acids, was not attacked by volatile alkali. An observation of Mr. Røering was published in the *Memoirs of the Academy of Stockholm* for 1783, which ascertains that the concretions expectorated by an old man subject to the gout, were found to be of the nature of bone, or phosphate of lime. But one of the newest and most important facts is that of Watson, in the *Medical Communications of London*, vol. i. 1784. He concludes, from the examination of the arthritic concretions of a gouty body, that this substance is very different from the matter of the calculus, since it is soluble in the synovia, and easily mixes with oil and water, which the calculus does not.

It follows from our observations on the lithic acid, that this acid is concrete, and sparingly soluble in water; that it is decomposed, and partly sublimed by distillation. This acid decomposes the nitric acid, unites with earths, alkalis, and metallic oxides. It yields its bases to the weakest vegetable acids, not excepting the carbonic.

C H A P. IX.

Concerning Phosphorus.

PHOSPHORUS is one of the most astonishing products of chemistry. It is pretended that traces of the knowledge of this substance exist in the writings of the earliest chemists: but the most positive information we possess on this subject is found in the history given by Leibnitz, in the *Melanges de Berlin* for 1710. He gives the discovery to Brandt, a chemist of Hamburg, who during a course of experiments upon urine, with a view of extracting a fluid proper to convert silver into gold, discovered phosphorus in the year 1667. He communicated his discovery to Kraft, who shewed it to Leibnitz; and being afterwards in England, he communicated it to Boyle*. Leibnitz caused the first inventor

* As Boyle communicated the process for making phosphorus to the Royal Society as a discovery of his own, and it is entered as such in the *Philosophical Transactions*, I cannot avoid animadverting on this impeachment of his integrity, which is copied from one chemical book into another. It is grounded on no better foundation than the assertion of Kraft,

inventor to be introduced to the Duke of Hanover, before whom he performed the whole operation; and a specimen of the phosphorus was sent to Huygens, who shewed it to the Academy of Sciences at Paris.

It is said that Kunckel had associated himself with Kraft to purchase the process from Brandt. But Kunckel having been deceived by Kraft, who kept the secret to himself, knowing that urine was made use of, set to work, and discovered a process for making the substance; and it is this which led chemists to call it by the name of Kunckel's Phosphorus.

Though the process was rendered public,

Kraft, a dealer in secrets, who, after having deceived his friend Kunckel, associated with him for the purchase of this secret. I might insist, in defence of the candour and otherwise unimpeached integrity of Boyle, that his assertion ought infinitely to outweigh that of the other. Not to insist, however, upon this, it may be noticed that this new and famous product was known to have been extracted from urine; that Kunckel is universally admitted as the discoverer, from his having formed it upon no fuller information than this; that Boyle might with equal probability be admitted to have discovered it in the same manner, and upon information equally slight; and that the probability of this is rendered incomparably greater, by the consideration, that none of these chemists made any complicated experiments, but merely applied the force of fire to urine until this product at last came over. T.

Kunckel,

352 *Processes for making Phosphorus.*

Kunckel. and a German called Godefred Hatwith*, were the only persons who prepared phosphorus for a long time. It was not till the year 1737, that it was made in the laboratory of the Royal Garden at Paris. A foreigner executed this operation in the presence of Messrs. Hellot, Du Fay, Geoffroi, and Du Hamel. An account of the operation may be seen in the volume of the Academy for 1737. Hellot has collected all the essential circumstances. Margraaf, in the year 1743, published a new and more easy method, which has been followed until Scheele and Gahn taught us to obtain it from bones.

The process of Margraaf consists in mixing the muriate of lead, which remains after the distillation of four pounds of minium and two of sal ammoniac, with ten pounds of the extract of urine of the consistence of honey. Half a pound of charcoal in powder is added; the mixture is dried in an iron pot until it is reduced to a black powder. This powder is to be put into a retort; and the volatile alkali, the fetid oil, and the sal ammoniac, distilled off. The residue contains the phosphorus. It is assayed by throwing a small quantity on hot coals: if it emits a smell of garlic, and a phosphoric

* Spelled Hanckwitz by most authors. He was instructed by Boyle. T.

flame,

flame, it is to be put into a good earthen retort, and distilled. Much more phosphorus is obtained by this than by the old process; and this depends on the addition of the muriate of lead by Margraaf, which decomposes the phosphate of soda, forming a phosphate of lead, which affords phosphorus; whereas the phosphate of soda is not decomposable by charcoal. The famous chemist of Berlin has likewise proved that it was the fusible salt of urine which affords the phosphorus.

Mr. Gahn published, in the year 1769, that the earth of calcined bones consisted of lime united with the acid of urine; but Scheele was the first to prove that by decomposing this salt of bones by the nitric and sulphuric acids, evaporating the residue in which the phosphoric acid exists in a disengaged state, and distilling the extract with powder of charcoal, phosphorus is obtained. These circumstances, related by Bergmann himself in his notes to the Chemistry of Scheffer, attribute to Scheele the discovery of extracting phosphorus from bones. It was not until the year 1775 that the process was published in the *Gazette Salulaire de Bouillon*. Additions and improvements have been successively made in this process, of which accounts may be seen in the *Dictionnaire Encyclopedique*.

The process which has most constantly succeeded with me, is the following :

The hardest bones are selected and burned. By this combustion the external part becomes white, while the internal part is blackish.

These burned bones must then be pulverized, and put into a turine, or in a round hooped wooden vessel. Half their weight of oil of vitriol is then to be poured on, and constantly stirred. During the agitation a considerable heat is excited. The mixture must be left in digestion for two or three days ; after which, water must be gradually added, and stirred. I digest this last mixture upon the fire, in order to increase the solvent power of the water.

The water of the lixivium is then to be evaporated in vessels of stone ware, silver, or copper. Mr. Pelletier recommends this last metal ; because, according to him, the phosphoric acid does not attack copper. The evaporation must be carried to dryness ; more boiling water must be poured on the residue ; and this washing must be continued until the matter be exhausted, which may be known by the water being no longer tinged yellow. All these waters are to be evaporated, and afford an extract.

To separate the sulphate of lime, the extract must be dissolved in the least possible quantity
 I of

of water, then filtered, and the salt remains on the filtre. This extract may be mixed with powder of charcoal, and distilled: but I prefer converting it into animal glass; for which purpose I put the extract into a large crucible, and urge the fire. It swells up at first, but at last settles; and at that instant the glass is made. This glass is white, of a milky colour. Becher was perfectly acquainted with it; but concealed his process, on account of the abuses which, according to him, might be made of it—*propter varios abusos*. He tells us, in proper terms, *homo vitrum est, et in vitrum redigi potest, sicut et omnia animalia*. He regrets that the Scythians, who drank out of disgusting sculls, were not acquainted with the art of converting them into glass. He shews that it would be possible to form a series of one's ancestors in glass, in the same manner as we possess them in painting, &c.

I observed once, to my great astonishment, that the phosphoric glass I had just made, emitted very strong electric sparks: these flew to the hand at the distance of two inches. I exhibited this phenomenon to my audience of pupils. This glass lost the property in two or three days, though preserved in a capsule of common glass.

It sometimes happens that this glass is deliquescent, but it is then acid; and this circum-

stance arises from too large a quantity of sulphuric acid, or from this acid not having been saturated by a digestion of sufficient continuance.

I have likewise obtained glass of the colour of turquoise, when I performed the evaporation in copper vessels.

This glass may be deprived of the bubbles it usually contains, by keeping it for a time in a violent heat; it is then transparent, and may be cut like a diamond. According to Crell, its specific gravity is to that of water as three to one, while that of diamond is as three and a half to one. This glass is insoluble in water, &c. A skeleton of nineteen pounds, burned, affords five pounds of phosphoric glass.

I pulverize this glass, mix it with equal parts of powder of charcoal, put it into a porcelain retort well coated, the beak of which I partly plunge into the water of the receiver, so that nothing can escape but air or phosphoric gas. I adapt a large tube to the tubulure of the receiver, and plunge it into a vessel filled with water. The fire being raised by degrees, the phosphorus comes over the moment the mixture is ignited. The phosphorus sublimes, partly in the form of a fume which congeals; and is precipitated upon the surface of the water, partly in the form of inflammable gas,
and

and partly resembling melted wax, which drops in beautiful transparent tears from the neck of the retort. The theory of this operation is easily explained. The phosphoric acid is displaced by the sulphuric acid, as is shewn by the large quantity of sulphate of lime which is obtained. All the other operations tend only to concentrate this phosphoric acid, which is still combined with other animal substances, and the distillation with charcoal decomposes the phosphoric acid; its oxigene unites with the coal, and affords carbonic acid, while the phosphorus itself becomes disengaged.

To purify the phosphorus, a piece of chamois leather is moistened, and the mass of phosphorus is put into it. This being immersed in a vessel of boiling water, the phosphorus melts, and is passed through the skin like mercury. The skin cannot be used more than once; the phosphorus, which might be passed a second time, would become coloured. This process was contrived by Mr. Pelletier.

In order to form phosphorus into sticks, a funnel with a long neck may be used, the lower orifice being closed with a small cork, or piece of soft wood. The funnel is then to be filled with water, and phosphorus put into it; and this being plunged in boiling water, the heat is communi-

communicated to that of the funnel ; and melts the phosphorus, which runs into the neck, and takes that form. The funnel is then removed into a vessel of cold water ; and when the phosphorus is perfectly cooled, the cork is taken out, and the phosphorus thrust out of its mould with a small piece of wood.

Phosphorus is kept under water. After a certain time it loses its transparency, becomes covered with a white powder, and the water is acidulated *.

In whatever manner phosphorus may be made, it is always one and the same substance, characterized by the following properties :— It is of a flesh colour, and evidently transparent. It has the consistence of wax ; and may be cut in pieces with a knife, or twisted asunder with the fingers ; in which last case the precaution must be taken of frequently plunging it into water, to prevent its taking fire.

When phosphorus is placed in contact with

* This slow acidification of the phosphorus seems to be reversed by the sun's light. Sticks of phosphorus, which had become covered with a white powder, were exposed under water to the sun's light, which converted them to an orange yellow colour in such parts as were acted upon by the direct light. This fact appears to be of the same nature as the colouring of the nitrous acid, and other similar phenomena. T.

the air, it emits a white fume. It is luminous in the dark; and a solid stick of phosphorus may be used to write with, like a crayon. The marks are visible in the dark; and this means has often been used to create fear and astonishment in the minds of the ignorant.

When phosphorus is exposed to twenty-four* degrees of heat, it takes fire with decrepitation, burns with a very bright flame, and emits a very abundant white fume, which is luminous in the dark. The residue of the combustion is a red caustic substance, which attracts the humidity of the air, and becomes resolved into a liquor. This is the phosphoric acid, which we shall proceed to treat of.

Mr. Wilson affirms that the solar rays set fire to phosphorus; and proves that this flame has the colour proper to the phosphorus, and not that of the ray itself.—Letter of Mr. Wilson to Mr. Euler, read at the Royal Society of London in June 1779.

* Twenty-four degrees of Reaumur answer to eighty-six of Fahrenheit. The vivid combustion of phosphorus takes place at different temperatures, according to its purity; but the present is very low. By taking phosphorus into a freezing atmosphere, its faint flame disappears, and it seems to require a temperature of sixty degrees to revive it. I found the vivid combustion to take place at one hundred and sixty degrees. T,

An

An advantageous use has lately been made of the combustible property of phosphorus, to procure fire conveniently, and in all situations, by means of phosphoric tapers or matches, and the philosophical bottles, the method of making which we shall point out.

1. The most simple process for making the phosphoric matches, consists in taking a glass tube, four inches long and one line in diameter, closed at one end. A small quantity of phosphorus is introduced into the tube, and pushed to its further end; after which a taper covered with a small quantity of wax is introduced into the same tube. The open end is then hermetically sealed, and the other end is plunged into boiling water. The phosphorus melts, and fixes itself upon the match.

A line is drawn at one-third of the length of the tube, with a flint, that it may be broken as occasion may require.

The match is to be drawn out quickly, to inflame the phosphorus,

The process of Mr. Lewis Peyla, to make the inflammable bougies, consists in taking a glass tube, five inches long, and two lines wide, one end of which is sealed with the blow-pipe. Small tapers of wax are prepared with three double threads of cotton twisted together. The
extre-

extremity of the match or taper is half an inch long, and must not be covered with wax.

A piece of lead is laid in a saucer filled with water; and upon this the phosphorus is cut, beneath the water, into fragments of the size of a grain of millet. One of these grains is to be dried, and introduced into the tube of glass; after which the fortieth part of a grain of very dry sulphur is to be added, that is to say, half the weight of the phosphorus. One of the bougies is then taken, and its extremity dipped in very clear oil of wax. If too large a quantity rises, it must be dried with a cloth.

The match is introduced into the tube with a turning or twisting motion between the fingers.

The bottom of the tube must then be plunged into boiling water, to soften the phosphorus; observing to keep it no longer than three or four seconds in the water.

The other extremity of the tube is afterwards sealed.

These bougies must be kept in a tin tube, to avoid the danger of inflammation.

2. To form the phosphoric bottles, a glass bottle is heated, by fixing it in a ladle full of sand, and two or three small pieces of phosphorus are then introduced into it. A small red-hot iron wire is used to stir the phosphorus about,

about, and cause it to adhere to the internal surface of the bottle, where it forms a reddish coating. The heated wire is introduced repeatedly; and when all the phosphorus is thus distributed within the bottle, it is left open for a quarter of an hour, and afterwards corked. When this is used, a common match tipped with sulphur is introduced into the bottle, turned round, and quickly drawn out. The phosphorus which sticks to the sulphur takes fire, and lights the match.

The theory of this phenomenon depends on the circumstance that the phosphorus is strongly dried, or half calcined, and needs only the contact of air to set it on fire.

Phosphorus is soluble in oils, more especially the volatile oils, which then become luminous. If this solution be kept in a bottle, a phosphoric flash, which emits a small quantity of light, will be seen every time the bottle is opened. The oil of cloves is used in this operation. The combination of phosphorus and oil appears to exist naturally in the glow-worm, *lampyris splendidula* Linnæi. Forster of Göttingen observes, that the shining matter of the glow-worm is liquid. If the glow-worm be crushed between the fingers, the phosphorescence remains on the finger. Henckel reports, in the eighth dissertation of his *Pyritologia*,

logia, that one of his friends, of a sanguine temperament, after having danced much, perspired to such a degree that he thought his life in danger. While he undressed, traces of phosphoric flame were seen on his shirt, which left yellow red spots behind them, resembling the residue of burned phosphorus: this light was long visible.

A phosphoric gas may be extracted from phosphorus, which takes fire by the mere contact of the air. Mr. Gengembre has shewn the method of extracting it, by digesting alkalis upon it (Memoir read to the Academy at Paris the 3d of May, 1783), and at the same time I shewed that it might be extracted by means of acids, which are decomposed upon phosphorus. I have likewise taken notice, in my Memoir upon the decomposition of the nitric acid by phosphorus, that when the acid is digested upon it, a gas escapes, which takes fire in the receiver, and has several times afforded me the appearance of flashes of lightning striking through the cavity of the vessels. But this phenomenon disappeared as soon as the vital air was absorbed.

It is to the disengagement of a gas of this nature that we may attribute the ignes fatui which play about burying-grounds, and generally in all places where animals are buried and
putrefy.

putrefy. It is to a similar gas that we may refer the inflammable air which constantly burns in certain places, and upon the surface of certain cold springs.

Phosphorus is found in the three kingdoms. Mr. Gahn found the phosphoric acid in lead. Siderite is a phosphorus of iron. The seeds of rocket, of mustard, of garden cresses, and of wheat, treated by Margraaf, afforded him a fine phosphorus. Mr. Meyer of Stetin has announced, in the Chemical Annals of Crell for the year 1784, that the green resinous part of the leaves of plants contains the phosphoric acid. Mr. Pilatre du Rozier renewed the opinion of Rouelle in 1780 (Journal de Physique for November), who considered the phosphoric acid as analogous to that of mucilaginous bodies; and he affirms that the distillation of pyrophorus affords five or six grains of phosphorus in the ounce. The phosphoric acid exists in urine, bones, horns, &c. Mr. Maret, by treating twelve ounces of beef by combustion, obtained three gros of transparent phosphoric glass. Mr. Crell obtained it from beef suet and human fat; Mr. Hankwitz from excrements; Leidenfrost from old cheese; Fontana from fishes bones; Berniard from egg-shells, &c. Messrs. Macquer and Mr. Struve found the phosphoric acid in the gastric juice.

The

The most interesting combination of phosphorus is that which it forms with vital air. This is always the phosphoric acid ; but the acid appears to be modified by the manner in which it is made.

Phosphorus unites with oxigene—1. By deflagration, or the rapid combustion. 2. By the slow combustion. 3. In the humid way, more especially by the decomposition of the nitric acid.

1. If phosphorus be exposed to a dry heat of twenty-four degrees, it takes fire, emits a white dense fume, and leaves a reddish residue, which powerfully attracts the humidity of the air, and becomes resolved into a liquor. This combustion may be performed under glass vessels; in which case white flocks are deposited on the sides of the glass, which resolve into a liquor by the contact of moist air, and form the phosphoric acid. Care is taken to introduce an additional quantity of vital air when the combustion of the phosphorus has not been completed.

Mr. Lavoisier has burned phosphorus, by the assistance of a burning glass, under a glass vessel plunged in mercury (Memoirs of the Royal Academy of Sciences, 1777.)

Margraaf had observed that air is absorbed in this operation. M. Morveau, in the year 1772, had

had declared the same from his own experiments; and Fontana proved that phosphorus absorbs and vitiates air, like every other combustible substance. Mess. Lavoisier and De la Place found that forty-five grains of phosphorus absorbed 65,62 of vital air.

The acid obtained by this means is impure. It always contains phosphorus in solution, not saturated with oxigene.

2. Phosphorus is most completely decomposed by the slow combustion. For this purpose the neck of a glass funnel is inserted into a bottle, and sticks of phosphorus are disposed round in the funnel, so as not to touch each other; a small piece of glass tube being put into the neck, to prevent their falling through. A paper is tied over the funnel. The phosphorus is slowly decomposed; and, as it becomes converted into a fluid, it flows into the bottle, where it forms a liquid without smell or colour. This acid almost always retains a small quantity of undecomposed phosphorus, from which it may be cleared by digesting alcohol upon it, which dissolves the phosphorus without volatilizing the acid.

One ounce of phosphorus produces in this manner three ounces of phosphoric acid.

3. The nitric acid may be decomposed by
digestion

digestion upon phosphorus. This nitrous gas is dissipated; and the oxigene remains united to the phosphorus, with which it forms phosphoric acid. When the nitric acid is very concentrated, the phosphorus takes fire, and burns at its surface. I published this process, with all the circumstances of the operation, in 1780, the same year in which the excellent Memoir of Mr. Lavoisier on the same question was printed, and of which I had then no knowledge.

The water in which phosphorus is kept, contracts acidity in the course of time; which shews that the water itself is decomposed, and yields its oxigene to the phosphorus.

Phosphorus precipitates some metallic oxides from their solutions in the metallic state. It is observed that acid is formed in this operation; which proves that the oxigene quits the metal to unite with the phosphorus.

The phosphoric acid is clear, inodorous, without being corrosive. It may be concentrated to dryness. Crell having concentrated it to dryness, found its specific gravity, compared with water, to be as 3.1.

This acid is very fixed. If it be concentrated in a matrafs, the water is first dissipated, a smell of garlic is soon perceived, which arises from a portion of phosphorus, from which this acid

C H A P. X.

Concerning certain Substances obtained from Animals for the Use of Medicine and the Arts.

THERE is not perhaps any animal product whose virtues have not been celebrated by some of the physicians; and there are few animals which have not at some time or other been mentioned as contributing to the advantage of medicine. Time however has happily condemned to oblivion those productions which ought never to have possessed celebrity: and we shall accordingly, on the present occasion, attend only to such as experience has shewn to possess the virtues and powers attributed to them.

We shall not therefore treat of the lungs of the fox, the liver of the wolf, the feet of the elk, the jaws of the carp, the nests of the swallow, the powder of the toad, the dung of the peacock, the heart of the viper, the fat of the badger, nor even that of the hanged malefactor.

Various quadrupeds, cetaceous animals, birds, and fishes, afford products in which chemical and medical experience has ascertained very evident virtues.

ARTI-

muriate of soda. This phosphate does not crystallize, but becomes converted into a gummy and deliquescent mass by evaporation. M. Sage affirms that the phosphate of soda prepared with the acid of the slow combustion, forms a salt susceptible of crystallization.

Dr. George Pearson has combined the phosphoric acid obtained by nitric acid with soda, and obtained a neutral salt in rhomboids.

This salt, though saturated, turns syrup of violets green, effloresces in the air, and has a saline taste resembling that of common salt. It purges in the dose from six to eight drams, without producing either nausea or griping, and has not a disagreeable taste.

The phosphoric acid acts only on a small number of metallic substances. On this subject the works of Mess. Margraaf and De Morveau may be consulted.

The phosphoric acid has a very evident action on oils. Mixed with an equal portion of olive oil, it acquires a fawn colour by mere agitation, which subsists even after the separation. This shade increases if the two fluids be digested together; the acid becomes thick; and the oil which floats above becomes black and coaly, and emits a strong smell.

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Various quadrupeds, cetaceous animals, birds, and fishes, afford products in which chemical and medical experience has ascertained very evident virtues.

ARTI-

ARTICLE I.

Concerning the Products afforded by Quadrupeds.

Under this article we shall treat of the products most in use which are extracted from quadrupeds. These are castoreum, musk, and hartshorn.

1. The name of Castoreum is given to an unctuous fluid contained in two pouches situated in the inguinal region of the male or female castor. An accurate description of it may be seen in the *Encyclopédie*. This very odorant substance is soft, and nearly fluid when recently extracted from the animal; but it dries in the course of time. It has an acrid, bitter, and nauseous taste; and its smell is strong, aromatic, and even stinking.

Alcohol dissolves a resin which colours it; water extracts an abundant principle. By evaporation of the water a salt is obtained, the nature of which is little known. Castoreum affords by distillation a small quantity of volatile oil, ammoniac, &c.

The uses of castor in the œconomy of the animal are unknown. The ancients had the

credulity to believe that the creature itself took it when its stomach was weak.

It is used in medicine as a powerful antispasmodic, in the dose of a few grains in substance ; and it enters as a component part into boluses, extracts, &c. It is advantageously joined with opium ; and its spirituous tincture is also prescribed in suitable liquids, in a dose from twenty-four to thirty-six drops.

We see clearly, from the little chemical information we possess respecting this substance, that it is a resin joined with a mucilage, and a salt which facilitates the union of its principles.

2. The name of Musk is given to a perfume obtained from various animals. In 1726 an animal was received, under the name of the Musk Animal, in the Royal Menagerie, which came from Africa, and resembled the civet. M. Perrault has left a description of it. It was supported six years upon raw flesh. M. De la Peyronnie gave a very good description of it to the Academy of Sciences for the year 1731.

The organ which contained the musk was situated near the genital parts (it was a female). At the aperture of the bag which contained the musk the smell was so strong, that M. De la Peyronnie could not inspect it without inconvenience.

convenience. This liquor is prepared by two glands, which transmit it into the common reservoir through a number of small perforations.

The other animal which affords musk in the East, is of the class of squirrels. It is very common in Chinese Tartary. It carries the musk in a bag beneath the navel. This bag, projecting outwards of the size of a pullet's egg, is formed of a membranous and muscular substance, provided with a sphincter. Many glands are observable within, which separate the humour. As soon as the beast is killed, this bladder is cut off and tied up: but its contents are adulterated with the testicles, the blood, and other offal of the animal: for each creature affords no more than three or four gros. Musk must be chosen soft, unctuous, and odorant; and ought to be consumed totally upon hot coals. The musk of Tonquin, which is most esteemed, is contained in bags covered with brown hair: but that of Bengal is covered with white hair.

Musk contains nearly the same principles as castoreum. The smell of pure and unmixed musk is too strong and oppressive. It is rendered mild by mixture with other substances. It is little used in medicine; is a powerful antispasmodic in some cases; but ought to be administered with caution, because it often
excites

excites nervous affections instead of calming them.

The smell of musk predominates in certain animals. M. de la Peyronnie knew a man from whose left arm-pit there was emitted so strong a smell of musk during the summer, that he was obliged to weaken it to avoid inconvenience.

3. Hartshorn affords several products which are much employed in medicine. The preference is given to this horn because it contains less earthy salt than bones ; but all kinds of horn may be used indiscriminately.

Hartshorn was formerly calcined with the greatest care, and used as a remedy against alvine fluxes.

The products of hartshorn which are mostly used at present, are those obtained by distillation. An alkaline phlegm is first obtained, which is called the Volatile Spirit of Hartshorn. Next comes over a reddish oil, more or less empyreumatic ; and a very great quantity of carbonate of ammoniac, foiled and coloured by the empyreumatic oil. The oil which colours the salt may be disengaged by means of spirit of wine, which dissolves it. The coaly residue contains natrum, sulphate, and phosphate of lime ; from which phosphorus may be obtained by the processes already described.

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The spirit and the salt obtained from hartshorn are used in medicine as good antispasmodics.

The oil duly rectified forms the animal oil of Dippel. As the highest virtues have been attributed to this substance, a thousand methods have been attempted to purify it. For a long time it was usual to rectify it a great number of times, in order to have it white and fluid. But Meff. Model and Baumé have advised taking only the first portion which comes over, because this is the most attenuated, and the whitest. Rouelle advises distillation with water; and as the most volatile part only rises with the heat of boiling water, there is a certainty of having it very fine by this means. For my part, I distil the empyreumatic oil with the earth of Murviel, which retains all the colouring part; and by this means I have it at once white and attenuated.

This is odorant, and has all the properties of the volatile oils: but it turns syrup of violets green, as Mr. Parmentier has observed; which proves that it retains a small quantity of volatile alkali. This oil is used in doses of a few drops in nervous affections, epilepsy, &c. It is used externally, by rubbing it on the skin; as a sedative, and to remove obstructions; but the great virtues formerly attributed to it are not much credited at present.

A R T I-

C H A P. X.

Concerning certain Substances obtained from Animals for the Use of Medicine and the Arts.

THERE is not perhaps any animal product whose virtues have not been celebrated by some of the physicians ; and there are few animals which have not at some time or other been mentioned as contributing to the advantage of medicine. Time however has happily condemned to oblivion those productions which ought never to have possessed celebrity : and we shall accordingly, on the present occasion, attend only to such as experience has shewn to possess the virtues and powers attributed to them.

We shall not therefore treat of the lungs of the fox, the liver of the wolf, the feet of the elk, the jaws of the carp, the nests of the swallow, the powder of the toad, the dung of the peacock, the heart of the viper, the fat of the badger, nor even that of the hanged malefactor.

Various quadrupeds, cetaceous animals, birds, and fishes, afford products in which chemical and medical experience has ascertained very evident virtues.

ARTI-

The nitric and muriatic acids have no action upon it.

Caustic alkali dissolves spermaceti, and forms a soap which gradually acquires solidity.

Alcohol dissolves spermaceti by the assistance of heat, but lets it fall as it cools. Ether likewise dissolves it.

The fixed and volatile oils dissolve it by the assistance of heat.

This substance was formerly much used. It was given as an emollient and softening remedy: but at present it is almost forsaken, and not without cause; for it is heavy, insipid, and nauseous.

The egg, the scales, and the black fluid of the cuttle-fish are still used in medicine. The eggs deterge the kidneys, and excite urine and the courses. The scales and bones of the cuttle-fish are applied to nearly the same uses: they are likewise used as an astringent; and enter into dentifrice powders, collyria, &c. The goldsmiths likewise use them to make their moulds for casting spoons, forks, toys, &c. because its spongy part easily receives the impression of metals. The black humour of the cuttle-fish, which is found in a bag near the cœcum, and of which Mr. Le Cat has given a description, may be used instead of ink. We read in the Satires of Persius that the Romans used it as an ink; and

and Cicero calls it Atramentum. It seems that the Chinese use it as the basis of their famous ink. "Sepia piscis est qui habet succum nigrissimum, instar atramenti, quem Chineses cum brodio orizæ, vel alterius leguminis, inspissant et formant, et in universum orbem transmittunt, sub nomine Atramenti Chinesis" (Pauli Hermani Cynosura, t. i. p. 17, par. 2.) Pliny was of opinion that the black humour of the cuttle-fish was its blood. Rondelet has proved that it is the bile. This is the fluid the cuttle-fish disgorges when in danger: a very small quantity is sufficient to blacken a large quantity of water.

Calcined oyster shells are likewise used in medicine as an absorbent.

The oil extracted from fish is of the greatest use in the arts. s

ARTICLE III.

Concerning certain Products afforded by Birds.

Most of the birds are used at our tables as a delicate food, but few afford any medical products. The eagle stones, to which so much virtue had been attributed for facilitating labours, the plasters of swallows nests, and other similar substances, have all fallen into neglect, as the natural consequence of the observation

servation of matter of fact being substituted in the place of credulity and superstition. The analysis of eggs begins to be known. They consist of four parts: an osseous covering, called the shell; a membrane which covers the constituent parts of the egg; the white; and the yolk, which occupies the centre.

The shell, like bones, contains a gelatinous principle, and the phosphate of lime.

The white is of the same nature as the serum of blood. It renders syrup of violets green, and contains uncombined chalk; heat coagulates it; by distillation it affords a phlegm which easily putrefies; it becomes dry like horn; and carbonate of ammoniac, and empyreumatic oil come over. A coal remains in the retort, which affords soda, and phosphate of lime. M. Deyeux has also obtained sulphur by sublimation.

Acids and alcohol coagulate it,

If it be exposed to the air in thin leaves, it dries, and becomes consistent; and it is on this property that the custom is founded of passing the white of egg over the surface of paintings, to give them that brightness which is produced by varnish, and also to defend them from the air. The drying may be hastened by quick-lime; and this mixture affords a lute of the greatest tenacity,

The

The yolk of egg likewise contains a lymphatic substance, mixed with a certain quantity of mild oil, which on account of this mixture is soluble in water. It is this animal emulsion which is known in France by the name of *lait de poule*. Yolk of egg exposed to the fire assumes a consistence less hard than the white. If it be bruised, it appears to have scarcely any consistence; and if it be subjected to the press, it gives out the oil it contains. This oil is very emollient, and is used externally as a liniment. There is the greatest analogy between the eggs of animals and the seeds of vegetables; since both contain an oil rendered soluble in water by the admixture of a glutinous substance.

The yolk of egg renders oils and resins soluble; and this substance is accordingly much used for that purpose.

Calcined egg-shells are an absorbent.

White of egg is successfully used to clarify vegetable juices, whey, liquors, &c. It coagulates by heat; and then rises to the surface of these fluids, carrying with it all the impurities they contain.

A R T I C L E I V .

Concerning certain Products afforded by Insects.

Millepedes, cantharides, kermes, cochenille, and lac, are the only substances we shall here treat of, because these are not only the most used, but are likewise the best known among the products of insects.

1. Cantharides.—The cantharides are small insects with greenish wings. They are very common in hot countries; and are found on the leaves of the ash, the rose-tree, the poplar, the walnut-tree, the privet, &c.

Cantharides in powder, applied to the epidermis, cause blisters, excite heat in the urine, strangury, thirst, and fever. They produce the same effect taken internally in a small dose. We read in Paré that a courtesan having presented a ragout powdered with cantharides to a young man who supped with her, this unfortunate person was attacked with a priapism, and loss of blood by the anus, of which he died. Boyle affirms that pains at the neck of the bladder have been produced by the handling of cantharides.

We are indebted to Mr. Thouvenel for some information respecting the constituent principles
of

of these insects. Water extracts a very abundant principle, which colours it of a reddish yellow, and also a yellowish oily principle. Ether takes up a green very acrid oil, in which the virtue of the cantharides most eminently resides. So that an ounce of cantharides affords—

			gros.	grains.
Reddish yellow bitter extract	—	—	3	0
Yellow oily matter	—	—	0	12
Green oily substance, analogous to wax	—	0	0	60
Parenchyma, insoluble in water and alcohol	—	4	0	0
			8	0

To form a tincture which unites all the properties of cantharides, a mixture must be made of equal parts of water and of alcohol, and the insects digested in it. If this tincture be distilled, the spirit which comes over retains the smell of cantharides.

If spirit of wine alone be used, it takes up merely the caustic part: hence it appears that the virtue of these insects may be increased or diminished according to the exigence of the case.

The tincture of cantharides may be used with success externally, in the dose of two gros, four gros, one or even two ounces, in rheumatic pains,

pains, sciatica, wandering gout, &c. It heats the parts; accelerates the circulation; excites evacuations by perspiration, urine, or stool, according to the parts to which it is applied.

Mr. Thouvenel tried upon himself the effect of the green waxy matter. When applied on the skin in the dose of nine grains, it raised a blister full of serosity.

2. The wood-lice, millepedes, aselli, porcelli. — This insect is usually found in moist places, under stones, or beneath the bark of old trees. It avoids the light, and endeavours to conceal itself when discovered. When it is touched, it rolls up in the form of a globe. This insect is used in medicine as an incisive, aperitive, and alterative remedy. It is prescribed either pounded alive, and put into a proper liquid; or dried and pulverized, in which last form they enter into extracts, pills, &c. The millepedes are given in the dose of fourteen, fifteen, twenty, or more, according to the exigency. Mr. Thouvenel has given us some information concerning the constituent principles of these insects. He obtained by distillation an insipid or alkaline phlegm; the residue afforded an extractive matter, an oily or waxy substance soluble in spirit of wine only, and marine salt with an earthy and an alkaline base.

3. Coche-

3. Cochenille.—Cochenille is a substance used in dyeing scarlet and purple. It is met with in commerce in the form of small grains of a singular figure, mostly convex with little grooves on one side, and concave on the other. The colour of good cochenille is grey mixed with reddish and white. It is at present well determined that it is an insect. Simple inspection with a magnifier sufficiently proves this; and the wings and feet of this insect may be developed by exposing it to the vapour of boiling water, or by digesting it with vinegar. The cochenille is collected in Mexico, upon plants to which the names of Indian Fig, Raquette Nopal, are given. These plants bear fruits which resemble our figs; tinge the urine of those who eat them; and probably communicate to the cochenille the property which makes it useful to the dyer. The Indians of Mexico cultivate the nopal near their habitations, and so far as it were the insect which affords the cochenille. They make small nests of moss or fine herbs, put twelve or fourteen cochenilles into each nest, place three or four of these nests on each leaf of the nopal, and fasten them there by the prickles of the plant: in the course of a few days, thousands of small insects issue out, and fix themselves upon the parts of the leaf
which

which are best sheltered, and afford the most nourishment. The cochenilles are collected several times in the course of the year : and are deprived of life by scalding them, or by putting them into an oven : after which they are dried in the sun. Two kinds of cochenille are distinguished : the one which is produced without culture, and is called Sylvestre ; and the other cultivated, which is called Mesteque. This last is preferred. It has been calculated, in the year 1736, that eight hundred and eighty thousand pounds weight of cochenille was annually imported into Europe. Mr. Ellis has communicated a very good description of the cochenille to the Royal Society of London.

This substance is more especially used in dyeing : its colour takes readily upon wool ; and the most suitable mordant is the muriate of tin. Mr. Macquer has discovered a method of fixing this colour upon silk, by impregnating the silk with a solution of tin before it is plunged into the bath of cochenille ; instead of mixing a solution in the baths, as is done for woollens.

4. *Kermes*.—*Kermes* is a kind of excrescence, of the size of a juniper-berry, which is greatly employed in medicine and the arts.

The tree which bears it is known by the
Vol. III. C c name

name of *Quercus Ilex*. It grows in hot countries; in Spain, Languedoc, Provence, &c. The female of the coccus fixes itself on the plant: it has no wings, but the male has. When she is fecundated, she becomes large by the development of her eggs: she perishes, and the eggs are hatched. It is collected before the development of the eggs; for which purpose, the morning is taken, before the heat has acted upon the eggs. The grains are collected and dried, to develop the red colour; they are then sifted, to separate the powder; and lastly they are sprinkled with good vinegar, to kill the insect, which would otherwise come forth in a short time.

Kermes is much used in the arts: it affords a good red, but less brilliant than that of the cochenille.

A very celebrated syrup of kermes is made, by mixing three parts of sugar with one of the grains of kermes pulverized. This mixture is kept for a day in a cool place: the sugar during this time unites with the juice of the kermes; and forms with it a liquor which, when drawn off by expression, has the consistence of syrup. The celebrated *confectio alkermes* is made with this syrup.

The grains of kermes given in substance,
from

from half a scruple to a gros or dram, are celebrated for preventing abortion.

The grain and the syrup of kermes, are an excellent stomachic.

5. Lac, or gum-lac.—This is a kind of wax, collected by red winged ants from flowers in the East Indies, which they transport to the small branches of the tree where they make their nests. The nests are full of small cells, in which a red grain is found when the mass is broken. This small grain is, to all appearance, the egg from which the flying ant derives its origin.

Mr. Geoffroy has proved, in a Memoir inserted among those of the Academy for the year 1714, that this must have been a kind of comb, approaching to the honeycomb of bees, the cells of which are formed of a substance analogous to wax *.

The colouring part of lac may be taken up by water, which, when evaporated, leaves the colouring principle disengaged. It is the fine

* For a description and drawing of the insect which affords the lac, consult Keir in the *Philos. Transf.* vol. lxxi. p. 374; also Saunders, in the same work, vol. lxxix. for the method of purifying the lac; or a short abridgment of both, in Nicholson's *First Principles of Chemistry*, p. 490. T.

lake used for dyeing. Lake is imitated by extracting the colouring principle of certain plants by well-known processes.

C H A P. XI.

Concerning some other Acids extracted from the Animal Kingdom.

INDEPENDENT of the acids afforded by the various parts of the human body, which have been separately examined by us, we find acids in most insects. Lister points out one which may be extracted from millepedes (Collect. Acad. tom. ii. p. 303). Mr. Bonnet has observed that the fluid ejected by the great forked-tail caterpillar of the willow was a true acid, and even every active (Savans Etrangers, tom. ii. p. 276): Bergmann compares it to the most concentrated vinegar. The abbé Boissier de Sauvages has remarked, that in that illness of the silk-worm, which is called muscardin, the humour of the worm is acid. Mr. Chauffier of Dijon obtained an acid from grasshoppers, from the May-bug, from the lampyris, and several other insects, by digesting them in alcohol. The same chemist has made an interesting
course

course of experiments on the acid of the silk-worm. He gives two methods of extracting it. The first consists in bruising the chrysalides, and straining them through a cloth. The fluid which passes is strongly acid; but the acid is weakened by various foreign substances, of which it may be cleared by digestion in spirit of wine. The fluid which passes the filter after this digestion, is of a fine orange colour. More spirit of wine is to be poured upon it. At every addition of spirit a light whitish precipitate is formed; and the additions of spirit are to be continued until no more precipitate appears.

Instead of bruising the chrysalides they may be infused in spirit of wine, which dissolves all the acid; and as this acid is less volatile than the spirit, this last may be evaporated, and the residue filtered. By these precautions the acid may be cleared of its spirit of wine, and of the mucous matter which was dissolved, but remains on the filter.

Mr. Chauffier has proved that this acid exists in all the states of the silk-worm, even in the eggs; but that in the egg and in the worm it does not exist in a disengaged state, but combined with a gummy glutinous substance.

The acid of insects which is best known, and upon which most has been written, is the acid

of ants, or the formic acid. This acid is so far in a disengaged state, that the transpiration of these animals, and their simple contact without any alteration, proves its existence.

The authors of the fifteenth century had observed, that the flower of chickory thrown into an ant-hill became as red as blood.—See Langham, Hieronimus Tragus, John Bauhin.

Samuel Fisher is the first who discovered the acid of ants, in a course of experiments for the analysis of animal substances by distillation. He even tried its action on lead and iron; and communicated his observations to J. Vray, who inserted them in the Philosophical Transactions in the year 1670. But it was the celebrated Margraaf who more particularly examined the properties of this acid in 1749. He combined it with many substances, and concluded that it greatly resembled the acetous acid. In 1777 this subject was again resumed by Messrs. Arvidsson and Oerhn; and treated in a manner which leaves little to be desired, in their dissertation published at Leipzig.

The ant which affords the greatest quantity of acid, is the large red ant which is found in dry and elevated places.

The months of June and July are most favourable for the extraction of this acid; they are then

then so penetrated with it, that their simple passing over blue paper is sufficient to turn it red.

Two methods may be used to obtain this acid; distillation, and lixiviation.

To extract the acid by distillation, the ants are first dried by a gentle heat, and put into a retort, to which a receiver is adapted, and the fire is raised by degrees. When all the acid is come over, it is found in the receiver mixed with a small quantity of empyreumatic oil, which floats upon it, and may be separated by a funnel. Messrs. Arvidsson and Oerhn obtained, in this manner, from each pound of ants seven ounces and a half of acid whose specific gravity, at the temperature of fifteen degrees, was to that of water as 1,0075 to 1,0000.

In the process by lixiviation, the ants are washed in cold water; and boiling water is afterwards poured over them, which is filtered when cold. More boiling water is poured over the residue, and likewise filtered when cold. By this means one pound of ants affords a pint of acid as strong as vinegar, and of a greater specific gravity. Messrs. Arvidsson and Oerhn are of opinion that this acid might be substituted instead of vinegar for domestic uses.

The acid obtained by these processes is never pure; but it may be purified by repeated distillations,

lations, which disengage the ponderous and volatile oil, and render the acid as clear as water. This acid, when rectified by this process, was found by Messrs. Arvidsson and Oerhn to have a specific gravity of 1,0011 to 1.

The acid of ants may likewise be obtained by placing linen cloths impregnated with alkali in an ant-hill. From these the formiate of potash, of soda, and ammoniac, may be obtained by lixiviation. The formic acid has some resemblance to the acetic acid; but the identity of these two acids has not yet been proved. Mr. Thouvenel found more analogy between it and the phosphoric acid: but all this wants proof.

The formic acid retains water with so much force, that it cannot be entirely deprived of it by distillation. When it is exceedingly pure, its specific gravity is to that of water as 1,0453 to 1.

It affects the nose and the eyes in a peculiar manner, which is not disagreeable. Its taste is penetrating and burning when pure, but agreeable when diluted with water.

It possesses all the characters of acids.

When boiled with the sulphuric acid, it turns black as soon as the mixture is heated. White penetrating vapours arise; and when it boils a gas is emitted, which unites difficultly with distilled

distilled water. or with lime-water. The formic acid is decomposed in this operation, for it is obtained in less quantity.

The nitric acid distilled from it destroys it completely ; a gas arises which renders lime-water turbid, and is difficultly and sparingly soluble in water.

The muriatic acid only mixes with it, but the oxygenated muriatic acid decomposes it.

Messrs. Arvidsson and Oerhn have determined the affinities of this acid with various bases in the following order: barytes, potash, soda, lime, magnesia, ammoniac, zinc, manganese, iron, lead, tin, cobalt, copper, nickel, bismuth, silver, alumine, essential oils, water.

This acid mixes perfectly with spirit of wine. It unites difficultly with the fixed oils, and with the volatile oils, by the assistance of heat. It attacks foot ; assumes a fawn colour ; and lets fall a brown sediment as it cools, which by distillation affords a liquor of a yellowish colour, and a disagreeable smell, accompanied with elastic vapours.

C H A P. XI.

Concerning Putrefaction.

EVERY living body, when once deprived of life, performs a retrograde process, and becomes decomposed. This decomposition is called Fermentation in vegetables, and Putrefaction in animal substances. The same causes, the same agents, and the same circumstances, determine and favour the decomposition of vegetables and animals, and the difference of the productions which are obtained, arises from the difference of the constituent parts of each.

Air is the principal agent of animal decomposition, but water and heat prodigiously facilitate its action. “ Fermentatio ergo definitur quod sit corporis densioris rarefactio, particularumque aërearum interpositio: ex quo concluditur debere in aëre fieri nec nimium frigido, ne rarefactio impediatur; nec nimium calido, ne partes raribiles expellantur.”—Becher, *Phys. Sub. lib. i. f. 5. p. 313. edit. Francofurti.*

An animal substance may be preserved from putrefaction by depriving it of the contact of
air;

air; and this process may be accelerated or retarded by varying or modifying the purity of the same fluid.

In those circumstances wherein we see putrefaction developed without the contact of atmospheric air, the effect is produced by the water which impregnates the animal substance, becomes decomposed, and affords the element and the agent of putrefaction. Hence no doubt it arises that putrefaction is observed in flesh closed in a vacuum.—See Lyons, *Tentamen de Putrefactione*.

Moisture is likewise an indispensable requisite to facilitate putrefaction; and any substance may be defended from this change by completely drying it. This was performed by Villaris and Cazalet of Bourdeaux, by means of stoves. The meat thus prepared was preserved for several years without having contracted any bad flavour. The sands and light porous earths preserve the bodies of men only by virtue of the property of exhausting their juices, and drying the solids. From this cause it is that entire caravans have been discovered in Arabia, consisting of men and camels perfectly preserved in the sands under which the impetuous winds have buried them. In the library of Trinity College of Cambridge, in England, a human body may be seen perfectly preserved,

preserved, which was found under the sand in the island of Teneriffe. Too much humidity impedes putrefaction, according to the observation of the celebrated Becher: "*Nimia quoque humiditas a putrefactione impedit, prout nimius calor; nam corpora in aqua potius gradatim consumi quam putrescere, si nova semper affluens sit, experientia docet: unde longo tempore integra interdum submersa prorsus a putrefactione immunia vidimus; adeo ut nobis aliquando speculatio occurreret, tractando tali modo cadavera anatomiae subjicienda, quo diutius a foetore et putrefactione immunia forent.*" *Phys. Sub. lib. i. f. 5. cap. 1. p. 277.*

In order therefore that a body may putrefy, it is necessary that it should be impregnated with water, but not that it should be inundated. It is likewise necessary that this water should remain in the texture of the animal body without being renewed. This condition is requisite—1. To dissolve the lymph, and to present to the air the most putrescible substance with the greatest extent of surface. 2. In order that the water may itself become decomposed, and by this means afford the putrefactive principle. Putrefaction is retarded and suspended by baking, because the flesh is dried, and by that means deprived of the humidity, which is one
of

of the most active principles of its decomposition.

A moderate degree of heat is likewise a condition favourable to the animal decomposition. By this heat the affinity of aggregation between the parts is weakened, and consequently they assume a stronger tendency to new combinations. Hence it arises that flesh meat keeps longer during the winter than in summer, and better in cold than in hot countries. Becher has given a very intelligent sketch of the influence of temperature on animal putrefaction. "Aër calidus et humidus maximè ad putrefactionem facit corpora frigida et sicca difficultèr, imo aliqua prorsus non putrescunt, quæ ab imperitis proinde pro sanctis habita fuere; ita aër frigidus et siccus, imprimis calidus et siccus, a putrefactione quoque preservat; quod in Hispania videmus, et locis aliis calidis, sicco-calido aëre præditis, ubi corpora non putrescunt et resolvantur; nam cadavera in oriente in arena, imo apud nos arte in furnis, sicari, et sic ad finem mundi usque à putredine præservari, certum est: intensum quoque frigus a putredine præservare; unde corpora Stockholmiae tota hyeme in patibulo suspensa sine putredine animadvertimus." *Phys. Sub. l. i. cap. i.*

Such

Such are the causes which are capable of determining and favouring putrefaction; and hence we may perceive the best means of preventing, increasing, or modifying it at pleasure. A body will be preserved from putrefaction by depriving it of the contact of atmospherical air: for this purpose nothing more is required than to place the body in a vacuum, or to envelop it in a covering which may defend it from the immediate action of the air; or else to envelop it in an atmosphere of some gaseous substance which does not contain vital air. We shall observe, on this subject, that the effects observed in flesh exposed in the carbonic acid, nitrogene gas, &c. are referable to a similar cause; and it appears to me that it is without sufficient proof that a conclusion has been drawn, that these same gases, internally taken, ought to be considered as antiseptic; because, in the cases we have mentioned, they act only by defending the bodies they surround from the contact of vital air, which is the principle of putrefaction. Putrefaction may be favoured by keeping bodies at a suitable temperature. A degree of heat from fifteen to twenty-five degrees diminishes the adhesion of the parts, and favours the action of the air: but if the heat be greater it volatilizes the aqueous principle, dries the solids, and

and retards the putrefaction. It is necessary, therefore, for the decomposition of an animal—

1. That it have the contact of atmospheric air; and the purer the air is, the more speedy will be the putrefaction. 2. That it be exposed to a moderate degree of heat. 3. That its texture be impregnated with humidity.—The experiments of Pringle, Macbride, Gardane, have likewise shewn us, that putrefaction may be hastened by sprinkling the animal substances with water containing a small quantity of salt; and it is to a like cause that we ought to refer several processes used in kitchens to produce this effect in food, as well as in the preparation of cheese, the curing of tobacco, the making of bread, &c.

Becher expresses himself as follows on the causes which produce putrefaction in living bodies:—"Causa putrefactionis primaria defectus spiritus vitalis balsamini est; secundaria, deinde, aër externus ambicus, qui interdum adeo putrefaciens et humidus-calidus est, ut superstitem in vivis etiam corporibus balsaminum spiritum vincat, nisi confortando augeatur; ex quo colligi potest, præservantia a putredine subtilia ignea oleosa esse debere."—This celebrated chemist concludes, from the same principles, that
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ligatures, copious bleedings, or any debilitation whatever, determines putrefaction. He likewise thinks that astringents oppose putrefaction only by condensing the texture of the animal parts; for he considers rarefaction or relaxation as the first effect of putrefaction. He thinks that spirituous liquors act as antiputrescent merely by animating and stimulating the vis vitæ. He affirms that the use of salted meats, which heat much, assisted by the moisture very common in ships and sea-ports, produces the scurvy; and he observes, with reason, that the tendency and effect of putrefaction are diametrically opposite to those of generation: “nam sicut in generatione partes coagulantur et in corpus formantur, ita in putrefactione partes resolvuntur et quasi informes fiunt.”

As the phenomena of putrefaction vary according to the nature of the substances themselves, and the circumstances which accompany this operation, it follows that it must be very difficult to describe all the phenomena which it exhibits. We shall therefore endeavour to trace only those which appear to be the most constant.

Every animal substance exposed to the air at a temperature above ten degrees of Reaumur, and moistened with its own serous humour, putrefies;

tries; and the progress of this alteration appears in the following order.

The colour first becomes pale; its consistence diminishes; its texture becomes relaxed; the peculiar smell of fresh meat disappears, and is succeeded by a faint and disagreeable smell. The colour itself at this time inclines to blue; as we see in game which begins to turn, in wounds which fall into suppuration, in the various parts threatened with gangrene, and even in that putrefaction of the curd which forms cheese. Most of our food suffers the first degree of putrefaction before we use it.

After this period the animal parts become more and more softened, the smell becomes fetid, and the colour of an obscure brown; the fibrous part easily breaks; the texture becomes dry, if the putrefaction be carried on in the open air; but the surface becomes covered with small drops of fluid, if the decomposition be made in vessels which oppose its evaporation.

To this period succeeds that which most minutely characterizes animal putrefaction. The putrid and nauseous smell which was manifested in the second degree, becomes mixed with a smell of a more penetrating kind, arising from the disengagement of ammoniacal gas: the mass becomes still less and less consistent.

The last degree of decomposition has its peculiar characters. The smell becomes faint, nauseous, and exceedingly active. This, more especially, is contagious, and transmits the seeds of infection to a great distance; it is a true ferment, which deposits itself upon certain bodies, to appear again at long intervals. Van Swieten reports, that the plague having appeared at Vienna in 1677, and having again appeared in 1713, the houses which had been infected at its first appearance were likewise infected at the second. Van Helmont asserts that a woman contracted an anthrax at the extremity of her fingers, in consequence of having touched papers impregnated with pestilential virus. Alexander Benedictus has written that pillows re-produced the contagion seven years after having been infected; that cords had remained infected for thirty years, and likewise communicated it, according to Forestus. The plague at Messina was for a long time concentrated in the warehouses where merchandize was inclosed with the suspected bales. Mead has transmitted the most alarming facts concerning the durable impression of contagion.

When the putrefying substance is in its last stage, the fibrous texture is scarcely discernible,
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and has no longer any appearance but that of a soft, disorganized, and putrid mass. Bubbles are seen to escape from the surface of this matter; and the whole ends by its drying, and becoming reduced to an earthy matter, which is friable when taken between the fingers.

We do not speak of the production of worms; because it appears to be proved that they owe their origin only to the flies which endeavour to deposit their eggs upon such bodies as are best suited to support the young they contain. If flesh meat be well washed, and left to putrefy under a sieve, it will pass through all the degrees of putrefaction without the appearance of worms. It has been observed that worms are of a different species, according to the nature of the disease, and the kind of animal which putrefies. The exhalation which arises from bodies, in these different cases, attracts different species of insects according to its nature. The opinion of those who believe in spontaneous generation, appears to me to be contrary to the experience and wisdom of nature, which cannot have committed the re-production and number of the species to chance. The progress of nature is the same for all the classes of individuals; and since it is proved that all the known species are re-produced in one and the

the same manner, how can we suppose that nature departs from her plain and general laws for the small number of individuals whose generation is less known to us?

Becher had the courage to make observations, during the course of a year, upon the decomposition of a carcase in the open air; and to observe all the phenomena. The first vapour which rises, says he, is subtile and nauseous: some days after, it has a certain sour and penetrating smell. After the first weeks, the skin becomes covered with a down, and appears yellowish; greenish spots are formed in various places, which afterwards become livid and black; a thick mossy or mouldy substance then covers the greatest part of the body; the spots open, and emit a sanies.

Carcases buried in the earth present very different phenomena; the decomposition in a burying-ground is at least four times as slow. It is not perfectly ended, according to Mr. Petit, till three years after the body has been interred, at the depth of four feet; and it is slower in proportion as the body is buried at a greater depth. These facts agree with the principles which we have already established for bodies buried in the earth, and subjected to laws of decomposition very different from those
which

which take place in bodies exposed to the open air. In this case the decomposition is favoured by the waters which filter through the earth, and dissolve and carry with them the animal juices. It is also favoured by the earth, which absorbs the juices with more or less facility. Messrs. Lemery, Geoffroy, and Hunaud have proved that argillaceous earths exert a very slow action upon bodies; but when the earths are porous and light, the bodies then dry very speedily. The several principles of bodies absorbed by the earth, or carried by the vapours, are dispersed through a great space, imbibed by the roots of vegetables, and gradually decomposed. This is what passes in burying-grounds in the open air; but it is very far from being applicable to the sepulchres which are made in churches and covered places. Here is neither water nor vegetation; and consequently no cause which can carry away, dissolve, or change the nature of the animal fluids; and I cannot but applaud the wisdom of government, which has prohibited the burying in churches; a practice which was once a subject of horror and infection.

The accidents which have happened at the opening of graves and vaults are but too numerous, to render any apology necessary for
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our speaking a few words respecting the method of preventing them.

The decomposition of a body in the bowels of the earth can never be dangerous, provided it be buried at a sufficient depth, and that the grave be not opened before its entire and complete decomposition. The depth of the grave ought to be such that the external air cannot penetrate it; that the juices with which the earth is impregnated may be conveyed to its surface; and that the exhalations, vapours, or gases, which are developed or formed by decomposition, should not be capable of forcing the earthy covering which detains them. The nature of the earth in which the grave is dug, influences all its effects. If the stratum which covers the body be argillaceous, the depth of the grave may be less, as this earth difficultly affords a passage to gas and vapour; but in general it is admitted to be necessary that bodies should be buried at the depth of five feet, to prevent all these unhappy accidents. It is likewise necessary to attend to the circumstance, that a grave ought not to be opened before the complete decomposition of the body. This decomposition, according to Mr. Petir, is not perfect until the expiration of three years, in graves of four feet depth; or four years when they

they are six feet deep. This term affords many varieties, according to the nature of the earth, and the constitution of the subjects buried in it; but we may consider it as a medium. The pernicious custom which allows a single grave to families more or less numerous ought therefore to be suppressed; for in this case the same grave may be opened before the time prescribed. These are abuses which ought to occupy the attention of government; and it is time that the vanity of individuals should be sacrificed to the public safety. It is likewise necessary to prohibit burying in vaults, and even in coffins. In the first case, the principles of the bodies are spread into the air, and infect it; in the second, their decomposition is slower and less perfect.

If these precautions be neglected; if the dead bodies be heaped together in too confined a space; if the earth be not proper to absorb the juices, and decompose them; if the grave be opened before the entire decomposition of the body—unhappy accidents will, no doubt, be produced; and these accidents are but too common in great towns where every wise precaution is neglected. An instance of this happened when the ground of the church of St. Benoit at Paris was dug up a few years ago:

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a nauseous vapour was emitted, and several of the neighbours were affected by it. The earth which was taken out of this grave was unctuous, viscid, and emitted an infectious smell. Messrs. Maret and Navier have left us several similar observations.

I N D E X.

N. B. The Roman Letters denote the Volume, and the Arabic Figures the Page. Where there is no Roman Letter the first Volume is to be understood.

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